Proceedings
9th Annual Conference
Risk Analysis:
Facing the New Millennium
Rotterdam – The Netherlands
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PREFACE

The European Section of the Society for Risk Analysis, SRA-Europe, recognises the relation between the next millennium and the need to effectively use existing knowledge and experience of risk assessment well. It is therefore with great pleasure we welcome you to Rotterdam and this 9th SRA-Europe Annual Conference under the heading of Risk Analysis: Facing the New Millennium.

Risk analysis is an established tool, with long experience in the traditional areas of technological risks, including non-technical issues such as risk perception, risk communication and decision making under uncertainty. At conferences and in journals dealing with risk issues attention is given to these traditional areas, but also new areas appear on the scene: health risks, food risks, mental risks, consumer risks. This is, of course, a positive and encouraging development showing the vividness of risk analysis as a scientific discipline. But do we know it all? Are there no challenges anymore? How do we communicate the existing body of knowledge to those who joined the analysis world later? Are we fully equipped to deal with the issue of integral safety of complex systems and decision making regarding the risks associated with large infrastructures in society (high speed train links, computer networking). Risk management is a keyword, which needs a broader focus.

The Society for Risk Analysis acts as the platform for permanent lessons for everyone who is part of the risk arena. Fundamental issues and practical problems are now presented at the SRA Annual Conferences and Meetings in Europe, the United States and Japan, and reported in both scientific journals: Risk Analysis and Journal of Risk Research. We would encourage the authors who contributed to this Proceedings to consider publishing a full paper in the SRA-Europe Journal of Risk Research. I requested JRR's editor to specifically consider papers from this conference.

CONFERENCE PROFILE

The conference addresses all major risk issues. SRA-Europe believes that learning from the past is a strong requirement for addressing risk issues in the new forthcoming century. We introduce a real risk by neglecting existing knowledge in upcoming areas of interest. The 1998 Annual Conference in Paris opened the process, the 1999 Annual Conference must continue this mission and must create a platform for permanent lessons in risk analysis. Contributions are presented in the various disciplines that encompass all traditional risk areas (technical risk, risk perception, risk communication), the integral approach to risk issues (risk management), new areas (multidisciplinary achievements in risk) and education in risk analysis.

East and West in SRA-Europe

Technological risks in the Eastern European countries have, in general, had too little attention under the old regimes. This has rapidly changed since 1991. The need to speed up the developments in the area of technological and ecological risks and the accompanying risk management are warranted urgently. The Eastern European scientists, of which many are represented in SRA-Europe, are capable of handling the risk problem, but lack of resources prevents them from keeping up fully with on-going developments in the West. In particular, the need for multidisciplinary approaches to bring people together to enhance cross fertilisation of available knowledge in the various disciplines is required. Further education in risk analysis and management and the application of scientific results in policy making for
existing and new risks will be discussed at the Conference, for example, the foundation of special Training Centres for risk analysis and risk management issues, which can give more Eastern European scientists the opportunity to get high level information on risk analysis methodologies at affordable price. They will also stimulate research in specific Eastern European risk issues.

ACKNOWLEDGEMENTS
Large numbers of abstracts and papers were handled and lots of matters had to be taken care of for having a well-prepared conference. It has all been handled excellently by the Conference Secretary, Gemma van der Windt, without whom the conference could not be a success. Her labour is really highly appreciated. I also want to thank the members of the National Organising Committee, the Technical Programme Committee and the Student Committee for their assistance and good ideas. I also want to thank Parthen R&S for handling the registration and the people at the Beurs/World Trade Center who take care of the conference locality. Assistance from numerous others not all mentioned by name and sponsors are also very much appreciated.

Delft, 1 September 1999

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Conference Director and Editor
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KEYNOTE SPEAKERS
HEALTH IMPACT OF LARGE AIRPORTS

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The paper will illustrate integrative risk assessment using the health impacts of major airports. It is based on a recent report of the Health Council of the Netherlands on this subject (report 1999/14E, published 2 September 1999). The report was prepared by a committee of experts convened by the Health Council; the committee members are listed below. The following text is a copy of the executive summary of the report.

EXECUTIVE SUMMARY OF THE REPORT:
PUBLIC HEALTH IMPACT OF LARGE AIRPORTS

CIVIL AVIATION

Civil aviation represents a growing industry and most economists expect this growth to continue. It is developing into a truly global industry, with a few conglomerates of airlines serving a world-wide network of large ‘hub’ airports. In 1997 the scheduled airlines carried 1.5 billion passengers and 26 million tons of freight.

The economic gains of the aviation industry and the possibility of reaching far away locations may be beneficial for health and quality of life, probably mainly so for affluent populations in the industrialised parts of the world. However, aviation affects the environment both globally and locally in a negative sense and consequently has also negative impacts on health.

REQUEST AND REPORT

This report responds to a request of the Ministers of Health, Transport and Environment of the Netherlands Government to assess the health impact of large airports. The request was related to the public and political debate about the future of the Dutch aviation infrastructure and about the expansion of Amsterdam Schiphol airport in particular, although a specific assessment for the Dutch National Airport was not called for. To prepare the report the President of the Health Council appointed an international committee of experts. Three case studies were carried out to provide the committee with background material on the way public health plays a role in airport development. The cases chosen were: a new passenger terminal at London Heathrow, Munich International Airport that opened at a new location in 1992, and the planning process for an airport in Berlin, to replace the three existing airfields in the beginning of the next century. The committee was also informed on the progress with the health impact assessment studies at Amsterdam Schiphol.

The committee focused on the public health impact of local changes in environmental factors. ‘Public health impact’ has been defined by the committee as to include impacts on ‘quality of life’. Effects of aviation on climate and thereby health and indirect positive and negative

2 These Cabinet Ministers are officially denoted by, respectively, Minister of Health, Welfare and Sport, Minister of Housing, Spatial Planning and the Environment, and Minister of Transport, Public Works and Water Management.
public health effects through economic mechanisms, transport possibilities and tourism are outside the scope of the present report.

Airport operations system
The committee has approached the relationship between airport operations and public health in an integrative manner. It evaluated public health impacts in airport operations systems encompassing the area up to a few tens of kilometres distance from the airport. Apart from the direct aviation related operations the system also includes the activities of businesses that are attracted to the airport region, as well as the infrastructure necessary to serve to airport, other businesses and the residential locations in the area. Even when airports are originally located in remote areas, then over of the years the airport region becomes more and more urbanised and settled with freight handling industries, catering and hotel activities, high-tech industries and offices that prefer to be located close to the airport.

The impacts of all these activities within an airport operations system on public health are only partly specific for the system. Aircraft noise, kerosene odour and aircraft crash risk are specific factors. Air pollution, landscape changes by transport infrastructure, road traffic and industrial noise and occupational health risks are, however, also encountered in other urbanised and industrialised settings.

Environment and public health
The committee has considered the impact of several environmental factors on health separately:

- air pollution
- noise
- accidents
- soil and water pollution at the airport
- importation of infectious diseases
- appearance of the environment
- occupational health risks at the airport.

In the concluding chapters the committee has tried to integrate these findings and suggests approaches for improving public health protection.

Does the airport operations system affect public health? This central question is answered by the committee with; yes. Considering the relationship between environmental factors and public health, infringements on the quality of life, such as sustained odour and noise exposure, also have a potential of causing clinically observable disease in the long run. This depends on a variety of factors such as individual susceptibility, social-economic status and lifestyle, and the simultaneous exposure to a variety of environmental factors. Some of these factors may aggravate the public health effects, but others could reduce or offset them. The relationships between environment and health are fraught with uncertainties, not in answer to the question about whether factors such as environmental noise and air pollutants do affect public health negatively, but to the questions as to what extent and which population groups are most vulnerable.

In determining the impact of environmental factors the committee uses classification schemes for:

- evidence for the causal relationship between the exposure to an environmental factor and a public health effect
- severity of the effect (slight, moderate, severe)
- number of people affected.

The classes for causal evidence are; sufficient, limited or inadequate evidence, or evidence for the lack of a causal relationship. Severe effects seriously impair day-to-day functioning and
usually require professional medical care. A public health effect is rated as ‘slight’ if the impact on daily functioning is not very significant, or is reversible, or has a small effect in the long run. Moderate effects are in between these two extremes. The number of affected people can only be very roughly indicated. Classes are: susceptible individuals, specific subgroups, substantial part of the exposed population, and are only given if the causal relationship is deemed to be supported by sufficient evidence.

AIR POLLUTION

The contributions from aircraft, other airport operations, road traffic to or from the airport or to other destinations to the public health effects of air pollution in an airport operations system are intricately mixed. This is due to the spread of air pollutants in the atmosphere by dispersion processes, whereas total pollution is also determined by sources outside the system, possibly far away. The important conclusion is that air pollutant levels around large airports are similar to those in urbanised areas and are to a large extent determined by road traffic emissions. At such concentrations public health effects are to be expected, even though the concentrations are generally below official guideline values.

The present understanding of air pollution effects is that exposure will impair respiratory functions, for most people in a reversible way. Effects become more invalidating in the case of sustained exposure. The table below lists the effects of air pollution for which there is sufficient scientific evidence for a causal relationship:

<table>
<thead>
<tr>
<th>response</th>
<th>severity</th>
<th>number affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>premature death (response after an episode in susceptible groups)</td>
<td>***</td>
<td>*</td>
</tr>
<tr>
<td>aggravation of respiratory and cardiovascular disorders after an episode</td>
<td>***</td>
<td>*</td>
</tr>
<tr>
<td>in hospital admissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>affected lung function after an episode</td>
<td>*</td>
<td>?</td>
</tr>
<tr>
<td>premature death (decrease in life expectancy) due to chronic exposure</td>
<td>***</td>
<td>*</td>
</tr>
<tr>
<td>reduced lung function due to chronic exposure</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>increase in chronic respiratory conditions (bronchitis) due to chronic exposure</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>odour annoyance from chronic exposure</td>
<td>*</td>
<td>***</td>
</tr>
</tbody>
</table>

1 * = slight, ** = moderate, *** = severe
2 * = susceptible individuals, ** = specific subgroups, *** = substantial part of exposed population

Effects, related to an air pollution episode, for which there is limited evidence are respiratory symptoms and aggravation of asthma. These effects are rated by the committee as slight and severe, respectively.

Epidemiological studies of the prospective, cohort and case-control variety have linked long-term exposure to air pollution with survival, increased lung cancer mortality, reduced lung function and increases in chronic respiratory conditions, especially bronchitis. The committee rates this evidence as sufficient, even though more work need to be done to elucidate exposure-response relationships. There is to date only inadequate evidence to link long term exposure to community air pollution to the prevalence of allergy and asthma. As yet no airport specific carcinogenic compounds have been identified.

The number of epidemiological studies on air pollution and public health near airports are scarce. Morbidity and mortality levels, related to diseases that may be air pollution related, do not appear to differ between airport regions and cities. A study at Amsterdam Schiphol has provided evidence for a decrease in the prevalence of respiratory complaints with increasing distance from the airport. To what extent air pollution levels and other factors play a role is subject of further study.
Chronic exposure to odour has been reported to induce, apart from annoyance, a variety of moderate somatic and psychosomatic effects. The evidence for a causal relationship is rated as limited.

With respect to controlling air pollution the committee notes that in most industrialised nations industrial and road traffic sources of air pollution are subject to regulatory control, contrary to aircraft emissions. An integrated approach to combat air pollution is at odds with a system in which one important source, *i.e.* aircraft emissions, is exempt from such control.

**NOISE**

Aircraft noise is one of the most noticeable environmental factors of airport operations and is specific to the system. Although there are other noise sources in the system, noise from aircraft taking off and landing, from aircraft braking and taxiing at the airport and from aircraft engine testing are dominant ones. At the airport, noise from ground traffic can be considerable and will in particular affect airport workers. In the vicinity of an airport one will usually find residential locations where air traffic noise is a dominant source of environmental noise exposure. Aircraft noise levels are determined by the position of the runways and the flight patterns. Outdoor aircraft noise exposure in residential areas around large airports may exceed 60 and occasionally 70 dB(A) (day-night or day-evening-night exposure level).

Hearing impairment is a well-documented effect of noise exposure. In an airport operations system it is of concern at operations at the airport, especially in ground handling and in engine testing. Only in very exceptional cases will environmental noise exposure induce hearing loss. The other effects for which there is sufficient evidence for a causal relationship with noise exposure are listed in the table below. Effects are only observed in exposed populations at noise levels above the observation threshold. ‘Sleep disturbance’ in the table denotes a conglomerate of effects, including awakening, sleep stage and sleep pattern changes, heart rate changes, and effects on mood the next day. Limited evidence exists for the effects of night-time noise exposure on performance the next day and changes in hormone levels. A variety of other effects has been linked to noise exposure, such as decreased general performance, biochemical effects, deterioration of the immune system, decrease in birth weight, psychiatric disorders and negative effects on psycho-social well-being. The committee considers the evidence for the causal relationship of these phenomena with noise exposure to be limited. With the exception of psychiatric disorders (severe), and effects on birth weight and psycho-social well-being (moderate), the committee rates the other effects as slight. There is evidence that congenital effects do not result from the exposure of pregnant women to environmental noise.

The understanding of the committee is that, hearing impairment excepted, the public health effects of noise depend on both the (psychological) appraisal of the noise exposure by the organism and the vegetative reactions induced. Some of the somatic and psychosomatic effects, such as hypertension and cardiovascular disease may be a direct consequence of this processing of noise exposure by the organism, others are possibly a consequence of noise-related annoyance. Annoyance is defined here as a feeling of resentment, displeasure, discomfort, dissatisfaction or offence which occurs when an environmental factor interferes with a person’s thoughts, feelings or activities. Noise exposure is only one of the determinants of annoyance. Studies have shown that aircraft noise is more annoying than road and rail traffic noise at the same day-night exposure levels. Aircraft noise-induced annoyance is influenced by the degree of anxiety associated with the possibility of aeroplane crashes. Other so-called non-acoustical factors that modify annoyance are the degree of openness on the part of the airport authorities or the government concerning
the developments at the airport and the way in which the authorities enforce environmental standards. These latter factors can work both ways, i.e. they can be instrumental in reducing (more openness, strict enforcement) or increasing annoyance.

<table>
<thead>
<tr>
<th>response</th>
<th>severity</th>
<th>number affected</th>
<th>observation threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypertension</td>
<td>**</td>
<td>**</td>
<td>eq. outdoors sound level (06-22 h) of 70 dB(A)</td>
</tr>
<tr>
<td>ischaemic heart disease</td>
<td>***</td>
<td>*</td>
<td>eq. outdoors sound level (06-22 h) of 70 dB(A)</td>
</tr>
<tr>
<td>annoyance</td>
<td>*</td>
<td>***</td>
<td>outdoors day-night level of 42 dB(A)</td>
</tr>
<tr>
<td>sleep disturbance</td>
<td>**</td>
<td>***</td>
<td>depending on effect, indoors SEL of 35-50 dB(A)</td>
</tr>
<tr>
<td>performance at school</td>
<td>**</td>
<td>**</td>
<td>eq. outdoors sound level (school hours) of 70 dB(A)</td>
</tr>
</tbody>
</table>

1 * = slight, ** = moderate, *** = severe
2 * = susceptible individuals, ** = specific subgroups, *** = substantial part of exposed population
3 threshold for 'high annoyance'; the day-night level is the equivalent sound level over 24 hours, with the sound levels during the night (period of 23-07 h) increased by 10 dB(A).
4 SEL is the equivalent sound level during the noise event normalised to a period of one second

Recent studies appear to confirm older work on the negative impact of aircraft noise on the cognitive abilities of children. The committee deems this to be a subject that warrants further study to elucidate exposure-response relationships and to assess the possible long term impacts.

SAFETY
Aircraft crashes come first to mind when mentioning safety in relation to airport operations. However, accidents, such as fires, may also occur (and have occurred) at fuelling operations and aircraft maintenance. Fires not related to fuelling can have severe consequences, especially those at the air, rail and bus passenger terminals. Also terrorist actions have been recognised as a serious risk associated with airports. Elsewhere in the airport operations system traffic accidents, accidents at industries, fires, etcetera can occur.

The present report focuses on aircraft crashes. The landing and takeoff stage are the most critical parts of a flight as far as crash risk is concerned. The probability of an accident further depends on the type of aircraft, its weight and its state of maintenance and the weather conditions. The management quality of the systems and organisations involved in aviation and in accident control, and the quality of the managed personnel are components determining the accident risk. This holds for flight personnel, air traffic control, airlines and rescue and other safety services alike.

In the past decades world-wide, on average, 50 crashes occurred per year, resulting in about 1500 fatalities per year, among which 35 individuals of the general population. These data show that the primary victims are the crew and passengers. The services of the large airlines are associated with considerably less fatalities per aircraft hour than, e.g., general aviation (non-commercial aviation). Aircraft crashes are rare events given the large number of flights. At present the crash frequency in the vicinity of a large airport is roughly one to two crashes per ten million movements (takeoffs and landings). This implies that a rough estimate of the average crash rate in the vicinity of larger airports is one to two per decade.

Using the evidence, severity and number affected classifications accidents do occur (sufficient evidence), the health consequences are always severe and the whole population in the airport operations system is at risk, be it that only a small number of people will be actually affected. The individual risk levels for people living, working and travelling in the vicinity of a large airport are low (being hit by a crashing aircraft is a very extraordinary event) and will vary strongly geographically depending on the flight paths. Calculated individual risks (probability
per year of dying due to an accident at a given location) exceeding 1 per 10 thousand per year are confined, within the airport territory, to places close to the runways. Locations with calculated individual risks between 1 per 100 thousand and 1 per million per ear that encompass residential zones, have been identified around large airports. In the Netherlands around industrial installations new houses would only be allowed in zones with individual risk levels not exceeding 1 per million per year.

SOIL AND WATER POLLUTION
Leaking underground storage tanks and pipes, fuel spillage or leakage during ground handling of aircraft, washing of aircraft and vehicles and fire-training for which flame-retardant chemicals are used, are sources of water and soil pollution at airports. If policies to prevent such pollution are in force and effective, the public health impact is minor. A pollution pathway specific for airports is related to de-icing operations to prevent, for safety reasons, the formation of ice on aircraft parts and runways. Effects on humans due to exposure to all these compounds appear to be unlikely in practice.

Importation of infectious diseases by air traffic
World-wide air traffic increases the potential for transmission of infectious diseases from one country to another. An example is 'airport malaria', that occurs when mosquitoes infected with *Plasmodium falciparum*, originating at airports in regions where malaria transmission frequently occurs, contaminate people around airports elsewhere. The number of documented cases at present is small, but giving the growth of air transport the committee recommends airport authorities and airline companies to be vigilant.

OCCUPATIONAL HEALTH RISK
In general the nature of the work in the vicinity of the airport is not expected to have characteristics specific to the airport operations system. This is different for work at the airport and for the operation of aircraft, although for aviation ground personnel only the incidence of musculo-skeletal disorders appears to be higher than what might be generally expected. Accident mortality among pilots is increased, but flight crew mortality from other causes is not exceptionally different from what would be expected. Fatigue and job stress would be expected among air traffic controllers and flight crew, but research data do not point to specific problems. Although activities within the airport operations system do affect occupational health, the situation is not out of line with the situation in comparable industries.

COMPREHENSIVE PUBLIC HEALTH IMPACT ASSESSMENT
Environmental factors in an airport operations system operate in a cumulative way: people are exposed to, e.g., air pollution, noise and accident risk at the same time. People living in the vicinity of airports are not able to avoid exposure when performing everyday activities such as working, shopping, going to school, etcetera. Furthermore, the factors interact; for example anxiety related to aircraft crashes may enhance noise-induced annoyance and vice-versa. Other factors will modify the cumulative impacts. The visual appearance of the environment may act both in a positive and a negative sense, depending, e.g., on how well the traffic infrastructure has been embedded in the natural landscape. The availability of facilities, such as shops, public transport, parks, schools, will influence the way people rate their living environment and will also influence the public health impacts of factors that primarily or partly act via psycho-social mechanisms, such as noise and odour. Measures that increase the perceived control of people over their living environment may be beneficial in this respect.
Published results of comprehensive assessments of the public health impact of large airports, that would have allowed a definitive and complete answer to the Ministers’ request, are lacking. In fact, the health impact assessment study in progress at Amsterdam Schiphol is an exceptional example of what, in the opinion of the committee, should be normal practice. On the basis of such studies measures to safeguard public health effectively and efficiently can be implemented. The committee strongly recommends that public health impact assessment, to guide the further international development of the civil aviation system, become the norm instead of the exception.

WAY AHEAD

Airport and aviation development affect the lives of many people. Decisions to be taken are of a strategic nature and therefore require carefully and specifically designed procedures in which all stakeholders involved, including the people living in the vicinity of the airport in question, play a role. Although differing views on the significance of health and health effects, including impacts on quality of life, will make it difficult to reach consensus on the necessity and desirability of developments, a decision making structure in which those views can be discussed and are accounted for is preferable to autocratic decision making. The nature of the decisions to be made also require that mobility policies have to be discussed with the aim to let air transport be an integrated part of a sustainable mobility strategy.

Two approaches to reduce public health risk can be distinguished. On the one hand environmental quality standards can be set on a geographical basis (‘zoning’) and enforced by the government. In a different approach stakeholders ‘negotiate’ a comprehensive package of measures in which the negative effects of factors like noise, apart from being reduced by exposure limiting measures, are offset by improvements in the natural landscape, the quality of facilities in residential areas and an open communication between all parties concerned about developments at the airport and elsewhere in the system and about the measures taken to reduce noise exposure and air pollution. In practice a mix of both approaches will probably be used, depending on the prevailing political culture.

Aviation technology will have to innovate if the growth in air transport continues at its present rate. Already now large airports are congested and accident and near-accident frequencies might rise. Furthermore new technology is needed in order to lessen the public health impact of the expanding airport activities or in any case not aggravate it. The committee recommends that the technology development is accompanied by a technology assessment process that explicitly considers the short and long term environmental and health impacts of changes in technology.

Given the many parties involved in an airport operations system and given the interactions between different measures to reduce public health effects, the committee recommends that all developments are monitored and assessed on their public health consequences in an integrated manner. How such an integrated risk management structure reaches this goal is to be decided through the political process, but in order to be effective all parties involved should support such a structure and be willing to provide the necessary data in good time.

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INTRODUCTION
In spring 1999, actuality brought emphasis on two important food safety problems. The first was related to animal feed containing the cancer causing chemical dioxin, which contaminated Belgium and other European countries produced foods of animal origin exported world-wide. This event had Europe in the worst food safety crisis since Britain's mad cow disease outbreak. Following closely, millions of cans of Coca Cola products were recalled due to a rather mysterious chemical contamination which sparked further anxiety in Europe.

These two events have taken on the value of a symbol. They revealed that, in spite of a permanent improvement of the performance of the food industry at large and unprecedented efforts of public and private organisations to improve food safety, food systems are still vulnerable in this respect.

The purpose of this paper is not to develop the fundamentals of risk analysis: it is assumed that these are familiar to the audience. Rather it would highlight some general characteristics of the food safety risk, comment on the evolving approach to food safety risk analysis and potential difficulties, and, in this context, identify some of the necessary steps toward future progress, with particular consideration of the international dimension. The primary focus of this paper is on microbiological issues. Toxicological aspects of food safety will only provide some elements of comparison, but will not be addressed in details.

FOOD SAFETY RISKS: SOME GENERAL CHARACTERISTICS
Food may be the vector of multiple biological, chemical or physical risks whereas a combination of factors may affect the safety of the food supply and justify concerns about a potential increase in the incidence of foodborne accidents. Microbiological foodborne diseases continue to present a major problem of public health significance and a "sentinel" study indicated that in some European countries there are at least 30,000 cases of acute gastroenteritis per 100,000 population yearly (Notermans and van der Giessen, 1993). The role of new or re-emerging infectious agents is increasing. Recent examples of newly recognised agents are *E. coli* O157:H7, other pathogenic *E. coli*, *Campylobacter*, or *Cryptosporidium*. Old agents are re-emerging in new products or vehicles, such as *Salmonella enteritidis* in eggs. Micro-organisms are highly adaptable and changeable: for example, they may develop resistance to sub-lethal treatments, resist to sanitisers when trapped in biofilms, or develop antimicrobial resistance (e.g. *S. typhimurium* DT104). Many chemical hazards may also be associated with food. Foods are themselves a complex collection of naturally occurring chemicals that have nutritive and organoleptic functions, but which may have also pharmacological properties and occasionally toxic effects. Naturally occurring toxicants,
including seafood toxins and foodborne mycotoxins, present risks second only to those imposed by micro-organisms. Other chemicals may be introduced into foods intentionally (e.g. food additives) or unintentionally (e.g. migration into the final product of surface sanitizers, of components of packaging materials, of agricultural chemicals such as pesticides used on crops, of animal drug residues, of environmental or industrial contaminants). New issues of toxicology emerge. Allergic reactions cause increasing concern. Medical research has raised concerns about the effects of food constituents on hormonal function (a phenomenon referred to as endocrine disruption). Whereas the focus on carcinogens in food continues to consume substantial resources, advances in biomedical research are increasingly addressing the issues of teratogenicity, mutagenicity, genotoxicity and immunotoxicity. Foreign physical material in foods (e.g. stones, metal, wood, glass, and other physical objects) may become part of raw ingredients or further contaminate the products. Whereas continuing efforts have undoubtedly contributed to make food objectively safer than ever, it has to be appreciated that foodborne hazards present changing challenges to food systems that need to be appropriately addressed.

Vulnerability to food safety issues can also be sourced to the systems responsible for producing, manufacturing or distributing food (Theys, 1997). In this regard, such source systems are characterised by their dependence, their fragility, a relative opacity about the ways food safety is effectively ensured, and, finally, to some extent of managerial deficit. Over the past decades most of the efforts focused on scientific and technological advances aimed at preventing/controlling hazards in food. Today, the analysis of major food safety problems teaches that these are, most of the time, the consequence of organisation deficiencies. As a whole, the vulnerability of food systems, though inherent to their growing complexity, is somehow a sanction of a defective global organisation for approaching food safety issues.

Finally, it has to be appreciated that there exist a perceived increase in the social unacceptability of food safety risks. As food becomes objectively safer, the remaining and occasional risks are ever less tolerated by the public at large. This trend is enhanced by the tendency of the general public to feel more and more alien to food safety approaches and preventive/control activities where the related decisions appear to be mainly the affair of technological (e.g. the food industry) or administrative (e.g. the public agencies having jurisdiction) organisations. This results in a new perception of food safety risk which tends to bear the significance of an "outrage". There is an outrage where the risk is, in particular, coerced, industrial, controlled by others, linked with untrustworthy sources. The public wants outrage risks to be taken more seriously. Despite substantial progress in food science and food control, present technological or administrative approaches have paid less attention to the outrage, thus exacerbating the residual risk.

The principal lesson to be drawn from this overview is that managing food safety has become an increasingly complex business, as decisions in this field carry ever larger public health, economical or judicial consequences and may give rise to social debate and controversies. This has resulted in the search of ways to improve food safety decision making. With this regard, the development of a formal risk analysis approach has emerged as a useful tool. In the field of food safety, risk analysis has evolved since many years in the area of food toxicology (e.g. evaluation of food additives). Efforts to apply risk analysis in the field of food microbiology are much more recent. These will be specifically discussed in the following sections.
Internationally, a broad consensus has emerged about what should constitute a structured framework for food safety risk analysis, based on joint FAO/WHO expert consultations (FAO/WHO, 1995, 1997). This framework encompasses the three components of risk assessment, risk management and risk communication. Risk assessment follows from a clear statement of purpose, and includes hazard identification, hazard characterisation and dose-response assessment, exposure assessment and risk characterisation. Risk management includes risk evaluation (identification of the food safety problem, consideration of the problem in context and establishment of the risk profile, ranking of hazards for risk management and risk assessment priorities, establishment of a risk assessment policy, and, following the appropriate conduct of risk assessment, consideration of the risk assessment results), appraisal of risk management options, decision on the preferred option, implementation of options, monitoring, evaluation of effectiveness and possible review. Risk communication is co-extensive to all these activities. It is a two-ways process understood as an exchange of information and opinions about risk between risk managers, risk assessors and other parties concerned or affected by the problem and the decisions to be taken (the "stakeholders"). It is considered as crucial for open, transparent and effective decisions.

Against this general framework, it must be appreciated that, due to the novelty of the specific application of risk analysis to microbiological food safety issues, advances are uneven with regard to each of the basic components, whereas development and use of this process elements raise specific challenges.

Much emphasis is currently placed on microbiological risk assessment. It has to be appreciated that for many years, a large quantity of qualitative or semi-quantitative assessments have been performed by public authorities and industries world-wide, resulting in some sort of evaluation of the significance of foodborne hazards, whereas the risk as such (probability of human disease time exposure) was not considered nor evaluated directly. At present, advances are accelerating to develop a complete, quantitative microbiological risk assessment including the four recognised components, whereas many countries are presently in the process of building the necessary teams and surveying the available resources and information. However, the unique attributes of micro-organisms and of the host response raise specific difficulties (ICMSF, 1998).

Microbial risks are generally the result of one single exposure and each exposure to a pathogen or its toxin represent an independent, non-cumulative event (with the exception of particular fungal toxins). The levels of pathogenic bacteria and toxigenic fungi may change dramatically. For example, there can be billion-fold increase due to abusive storage and/or decrease as a result of a cooking process. In addition, pathogens are not voluntarily introduced into the foods, and their presence most usually results of accidents or defective practices in producing, manufacturing and handling. These potentials cast an important uncertainty on the determination of the probability of occurrence and importance of contamination and complicates in particular the acquisition and estimation of data for exposure assessment. Micro-organisms are dynamic and adaptable. They may acquire or loose virulence associated characteristics; they can have highly disparate disease-causing capabilities; they have various physiological mechanisms that may allow them to adapt to specific control measures; the virulence can also be affected by the food matrix in which they are present and by the conditions of ingestion. Microbiological risk assessment must therefore take into account the biovariability of the pathogens, and of the food itself, which are often rather difficult to approach.
The population response to infectious pathogens is substantially variable. It reflects in large part the variability in the immune status of humans; it depends on their genetics, age, physiological status, and on a variety of other biological or socio-economic factors. In spite of substantial efforts in understanding the biological processes involved in foodborne diseases, there is still in this area a large array of uncertainties. Since the disease process for infectious agents usually involves their multiplication in the host, there is often little correlation between the level of pathogens ingested and the severity of the disease response, particularly when considering exposure to low doses; there exist different mechanisms for pathogenicity (e.g. infectious, tox-i-infectious, toxigenic pathogens) which require different underlying assumptions in regard to dose-response relationship. In addition, secondary infections may result from other routes of contamination (e.g. person-to-person transmission of enterohemorrhagic E. coli, Shigella, Salmonella typhi) that need also to be taken into account when estimating the risk.

Thus, the microbiological risk assessment must deal with the inherent variability in the microbial population, in the human population, in the different possible production/manufacturing processes and their related parameters, and in the food. It has also to take into account the many uncertainties that permeate the whole tissue of our present knowledge.

Recent efforts to deal with these undeterminations have resulted in the proposal for using conceptual risk models. Such models are construed to integrate and structure the available information related i) to the characteristics of the pathogen, ii) to the characteristics of the process and the source that influence exposure (e.g. process pathways, process parameters, factors that may go wrong, relationship with product contamination and levels of microorganisms in food, consumption patterns and habits), iii) to the characteristics of health effects and of the affected population or sub-populations (e.g. duration, severity, outcomes of the disease, dose-response relationship, factors in the population that influence the severity of the disease). Based on this information, the model encompasses both a statistical approach (probability distribution of values, conditions, individuals) and a dynamic approach (evolution of microbial populations, of certain technical parameters such as temperature) and includes quantification of variables and mathematical description of their inter-relationship. The model may incorporate different types of mathematical sub-models, such as microbial predictive models or dose-response models. A particularly promising tool to be used in this context is the technique of stochastic modelling, such as Monte Carlo simulation, which use is now facilitated by a variety of software products presently available on the market. Stochastic modelling is intended to deal with undeterminations by determining the combined impact of the probability distribution of variables on the probability distribution of the possible model outcomes. The result represents a distribution of risk based on the probability of the values that could occur.

An important point however, is to note that there are some inherent limitations in the use of such conceptual risk models. The results are simulations of a probabilistic nature, and not observations: they should not be used inflexibly. Probably, the most important outcome of such models may not be a risk estimate, but rather an understanding of the factors that have the greatest impact on the risk (as approached for instance by subsequent sensitivity analysis techniques, e.g. Spearman rank correlation, Tornado diagrams) to aid in selecting the critical points that need intervention. Similarly, model experimentation (i.e. changing the values of input parameters according to hypothetical control strategies and observing the changes in the risk estimate) may aid in evaluating and comparing the robustness and efficacy of risk reduction options or mitigating measures (Cassin et al. 1998). In addition, the outcome of any model is only as good as the data utilised, which should be carefully evaluated as to their
availability, validity and quality. In this regard, it has to be appreciated that at present, considerable effort is being spent on research on pathogenic agents identification, on their monitoring in the production to consumption continuum, on the surveillance of foodborne diseases, all these providing data that are necessary for microbiological risk assessment. However, though essential, less activities are developed on characterisation of virulence factors of micro-organisms, on dose-response modelling and on characterisation of host-pathogens interactions. Likewise, and in spite of substantial developments in the mathematical aspects of risk modelling, little effort has been spent in optimising risk characterisation, and in particular in integrating a measure of public health effects to characterise the population risk in a way that is useful to risk managers.

Risk assessment is not a standalone process: it should be considered within an overall risk management framework. In this regard, elements of the "risk analysis" framework have been applied in one form or another by regulatory authorities and private companies for the management of microbiological hazards and risk of concern with regard to food safety. However, critical analyses suggest that a systematic strategy has yet to be developed, whereas specific issues require further clarification both at a national level and with regard to international trade considerations.

One of these issues refers to linking the development of microbiological risk assessment with managerial needs. Though obviously correlated to actual problems or concerns (e.g. *Listeria monocytogenes* in milk or milk products, in ready to eat foods; *Salmonella enteritidis* in eggs and egg products; verotoxigenic *E. coli* in ground beef etc.), most presently published microbiological risk assessments have been essentially the result of methodological research initiatives of groups or individuals, often without clear statement of purpose. Most importantly, the essential managerial task of establishing a policy for risk assessment has been generally overlooked. Certainly, the overriding principle of protecting the independence and integrity of risk assessment is universally recognised. However, there is little, if any, internationally recognised guidance on how to implement this principle in practice (i.e. what does it takes for risk assessment to be functionally separated from risk management, whereas some interactions are necessary). Also, no guidelines have been discussed, let alone internationally established, for value judgement and policy choices which may need to be applied at specific decision points in the microbiological risk assessment process, including for instance guidelines for judging adequacy of data sets, type and range of the risk assessment, qualitative versus quantitative approaches, ranking of different classes of adverse health effects, dealing with uncertainty (e.g. validity and potential for use of "safety factors", at times advocated by analogy with chemical risk assessment). In most present situations, these have been left to the discretion of the assessors themselves and handled on an ad hoc basis. It should be appreciated that such treatment would impinge on the credibility of the risk assessments and may lead to untransparent processes that leave many assumptions (and extra-scientific issues) hidden, thus severely limiting the value of most present approaches for consistent and transparent international policy decisions and standards setting.

Another important point is that, at present, there exist almost no formal element of risk management with particular regard to what constitutes an "appropriate level of protection" (referred otherwise as to the "acceptable" or "tolerable" level of risk). Examples exist in different sectors (e.g. for industrial risk, or nuclear protection). It is amazing that this issue has not been discussed among the scientific and public health communities with regard to microbiological food safety issues.

These present shortcomings create the greatest challenge with regard to international trade considerations, with particular reference to elaborating standards for food in international trade. The ratification of the WTO agreements, the SPS (Sanitary and Phyto-Sanitary)
agreement in particular, brings an internationally agreed discipline to the definition and application of sanitary measures. Briefly summarized, these rules establish that sanitary measures must be based on scientific evidence or on an assessment of the risk as appropriate to the circumstances. Also, the equivalence of sanitary measures must be accepted if an exporting country can objectively demonstrate that its sanitary measures provide the importing country's appropriate level of protection. Nevertheless, the agreement upholds the right of countries to determine what constitutes such an "appropriate level of protection". The desire of the WTO for scientifically justified food safety measures needs to be tempered according to the ability of the global scientific community to generate necessary data quantified to the largest extent possible, agreed-upon microbiological risk assessment procedures, and internationally agreed risk management framework for decision making on acceptable level of microbiological food safety (Hathaway and Cook, 1997). In addition, the issue of international risk management according to the SPS provisions of the WTO agreements is further complicated at present by the uncertain outcome of discussions about the extent to which factors other than scientific ones (the so called "other legitimate factors") should be considered at an international level.

Finally, while risk communication and involvement of stakeholders is recognised as a fundamental principle for risk analysis, there is still a general deficit in this field. Governmental offices assume large responsibilities with regard to the development of microbiological risk assessment. Involvement of other groups of stakeholders is only but occasional, as it is also with regard to making decisions. This is probably the consequence of the traditionally heavy involvement of public authorities in regulating microbiological food safety matters. To day, this does not fit so well with the growing pressure for openness and multipartner communication advocated in risk analysis developments. This shortcoming may have resulted in difficulties in exchanging and disseminating information and data necessary for more accurate assessments as well as for orientating, and more importantly, in calibrating immediate or "emergency" interventions where necessary. It may also undermine the expectations placed in risk analysis as a tool intended to facilitate and to legitimate the multidimensional, value-laden decisions that shape microbiological food safety.

WAY FORWARD
The previous comments should not be misunderstood. They are not intended to cast doubt on the interest and practicality of (microbiological) food safety risk analysis. To the contrary, they are presented to highlight the "newness" of the approach in this field, and to identify areas where substantial efforts should be concentrated. These will be presented briefly, in the form of a strategic action plan, as detailed information on particular needs is available in many specific documents.

Due to the pressing international drive for scientifically justified sanitary measures, there is primarily a need to improve the reliability, the credibility and the transparency of microbiological risk assessments. Efforts should be developed in regard to organisation, support actions, and operation.

Regarding organisation, it is crucial, first, to establish credible scientific sources (formal expert groups), at national and international levels. To that aim, selection of assessors should fulfil the three criteria of excellence (experts should be recognised scientists), of independence (experts should not have interests associated with any particular group of stakeholders regarding the problem at stake), and of transparency (full access of interested parties to selection procedures; interests of experts, if any, disclosed whereas it should be ensured that these do not result in a bias in the risk assessment). Second, there is a need to develop appropriate policy for risk assessment. The policy should be documented and contain the four
values of transparency, clarity, consistency, and reasonableness, with transparency in the risk assessment process and clarity, consistency and reasonableness in the risk assessment products (Ohanian et al. 1997). Third, it is necessary to provide for internal operating procedures and peer review, to ensure the integrity of each risk assessment and that adequate characterisation is carried out. Fourth, a strategic planning of work should be developed, to make the best use of staff, time and money, while having regard to establishing priorities.

Regarding support actions, there is basically a need to develop research programmes aimed at filling critical microbiological food safety information gaps and at developing appropriate models and methods that account for the specificity of microbiological food safety problems. In addition to an improved characterisation of pathogens, the microbiological risk assessment paradigm require more quantitative data to ascertain the exposure of consumers and to ascertain the dose-response relationship. Specifically with the latter, models need to be further developed and, moreover, experimentally and theoretically evaluated. Where information exists, it has to be appropriately managed. Two activities are essential: identification of datasets, and organisation for access and retrieval. Communication and involvement of stakeholders are crucial in this respect. Also, knowledge and skills necessary to perform risk assessments need to be identified and provided by specific training and on-going education.

Regarding operation, there is a need to combine to the largest extent possible the traditional hazard oriented approach with a public health perspective to develop a holistic appreciation of microbiological food safety problems in their context, in order to enhance consistency in risk reduction strategies. To limit controversies as to the information utilised, risk assessments should include a "weight-of-evidence" approach: all reliable information should be considered, including positive and negative studies as well as minority views; assessors should give to the information utilised a peer-review status (e.g. assessment of quality, adequacy of experimental design and conduct, consistency of results); they should present the plausible conclusions about risk, along with the evaluation of the scientific weight of evidence that support assumptions and conclusions. Most importantly, there is a need to improve the final presentation of risk characterisation, to facilitate bridging the risk assessment process with decision-making (Ohanian et al. 1997). Risk characterisation should encompass two components: i) an estimation of the risk, that is objective, realistic, credible and scientifically balanced, ii) a descriptive explaining confidence in the risk assessment, delineating the uncertainties and their sources, the assumptions along with their impact on the overall assessment, possible alternative views and differences in the risk estimate based on different assumptions. In particular, quantitative estimates should wherever possible be expressed as ranges or distributions; all risk characterisation should explicitly address variability and uncertainty, whereas these should be separated to the extent feasible; all assumptions should be fully acknowledged and their impact thoroughly assessed and discussed; risk characterisation should associate mathematical estimates of the risk and qualitative information (narratives) to ensure that the non-scientists that will use the risk assessment get a clear message on the nature, the likelihood and severity of the risk, together with an understanding of the plausibility, strengths and limitations of the assessment.

With regard to the international dimension, and to facilitate development of common and comparable approaches to microbiological risk assessment, channels for international communication and co-operation in these different areas should be established and developed. In parallel with establishing an internationally agreed approach to microbiological risk assessment, there is also a need to achieve consistency in risk management. Basically, as risk analysis procedures develop, there is a need for risk managers (public authorities in particular, in the heavily regulated field of food safety) to understand their responsibilities in organising the whole process. They should develop appropriate structures and instruments to create an
institutional environment favourable to the development of documented, structured and credible risk assessments (see supra) and to foster a dynamic interrelationship and communication between all parties involved (governmental authorities, private industry, consumers, and supportive players such as research institutions or news media).

With regard to generic risk management issues, there is a pressing need to determine what should constitute an "appropriate level of protection". In a national system, this requires the establishment of risk based brightlines between unacceptable and negligible magnitudes of risk. It is important to realise that such brightlines can only be the result of a scientific production and of social arbitrage. Their establishment requires merging the scientific-analytical process of risk assessment with a socio-deliberative one aimed at appraising the different options in a societal perspective (technical feasibility, socio-economical aspects such as perception of the risk, values involved, equity considerations, or costs entailed), while ensuring involvement of stakeholders at all stages. This process would probably require, in addition to risk assessment, development and use of specific tools to provide a measure of the factors involved. For instance, an integrated measure of public health could be provided by measuring the health burden of foodborne illness, by way of scales like Quality or Disability Adjusted Life Years (DALY or QALY), as used in health economics and medical decision making (Havelaar et al, 1999). Economic analysis would be valuable inputs for risk-benefit and cost-effectiveness considerations. Also, advances in social sciences would be increasingly considered to provide important insights about consumers perceptions, preferences, equity and fairness issues. All of these would ensure that in addition to the scientific determinants of the risk, the diverse range of social, economic, and ethical values are taken into account in a systematic and equitable way.

This obviously creates the greatest challenge for international discussions. Due to the many factors involved, there is no reason to believe that there will be a common agreement on what should constitute a universal appropriate level of protection. Without contradicting the need to base decisions on the best science available, the problem is therefore to establish procedures to recognise that decisions taken at a national level are legitimate, transparent and non-arbitrary, and are not construed to be dissimulated non-tariff barriers. It has to be appreciated that, in this regard, the actual SPS agreement, with its narrow, deterministic reliance on science and risk assessment, may not provide totally adequate mechanisms. Will this call for innovative adjustments in the long run?

CONCLUSION
The French historian Eugène Cavaignac stressed that civilisation is "a minimum of science, art, order and virtue". Much the same with food safety risk analysis. It requires a minimum of scientific understanding of the nature and dimension of the food safety risk and its contributing factors, as embodied in risk assessment. It entails the art of sound judgement in making risk management decisions, in particular in the face of insufficient data or information. It requires order, the whole process being structured to a systematic and rational framework. Finally, it cannot work well without virtue, envisioned as the sought for legitimisation of decisions. In this regard, it is probably fair to ask the question: will risk analysis improve food safety? The answer depends primarily on the quality of the studies and processes involved. It relates also with the primary function risk analysis will be given in approaching food safety problems. Will it be an instrument for justification in the face of international trade requirements? Will it aim at preventing after-the-fact controversies? Will it rather contribute profound and durable changes in food safety risk management practices? Its use will determine its impact, whereas its success will require several years to be measured.
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CONCLUSION

The European Union’s vision is to create a “sustainable, efficient and virtuous” food system with food safety as a priority. Risk analysis is a scientific undertaking of the food safety risk assessment of the food safety risk, and its contribution is to the enhancement in food safety risk assessment. It requires a holistic approach to this subject. This paper is an attempt to integrate the concept of risk analysis with food safety. The analysis focuses on the outcome of the study and presents the results. It relates well with the primary document risk analysis, with the primary emphasis on food safety. This approach is intended to address the need for a food safety framework. The paper is written with an emphasis on the strengths and weaknesses of risk analysis and food safety. It presents an approach to food safety that is based on scientific evidence and risk analysis. The paper is an attempt to integrate the concept of risk analysis with food safety. It requires a holistic approach to this subject. This paper is an attempt to integrate the concept of risk analysis with food safety. The analysis focuses on the outcome of the study and presents the results. It relates well with the primary document risk analysis, with the primary emphasis on food safety. This approach is intended to address the need for a food safety framework. The paper is written with an emphasis on the strengths and weaknesses of risk analysis and food safety. It presents an approach to food safety that is based on scientific evidence and risk analysis.
WATER AT RISK
Water related risks and challenges in the 21st century

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ABSTRACT
Next century 50 - 80% of mankind will live in urban areas. So the 21st century will be the urban century. At the same time, 50 - 70% of the world population will live within a distance of 150 kilometres from the coast, so it will also be the century of the deltas and coasts. This poses many challenges, such as; water scarcity, pollution, overexploitation, famine and escalating conflicts over water, climate change, sealevel rise, floods and droughts. Each of them has the potency of unprecedented numbers of victims. Risks go beyond the physical dimension. Human behaviour and priorities in decision-making are very important. Many water related problems arise from human behaviour and priorities in decisions. Water related problems are caused by decision makers ignoring ecological laws, reinforced by alienation of nature of the 'urban man.' Pollution aggravates the problems. Most rivers in the world including their deltas, struggle with hydrological, quality and safety problems.

In this paper, burning issues at the end of the 20th century, concerning fresh water, rivers, deltas, coastal zones and seas are identified. Experiences with the Rhine riverbasin, its delta and adjacent sea are used to illustrate these issues. One of the most serious problems is the explosive growth in the demand for freshwater world-wide, combined with a decreasing supply per person per year, caused mainly by the explosive growth of the world population. There are many options to solve the problems. However this subject lies beyond the scope of this article. Relevant literature on the subject is suggested for an overview.

Fig. 1. Relative amounts of fresh and salt water in the world

RISKS GO BEYOND THE PHYSICAL DIMENSION
Water is vitally important to all life on earth, as well as fresh, brackish as salt water (Fig.1). Life is linked to all other living things through ecosystems and thus dependent on one another. Man is part of that life support system. By manipulating certain ecosystem processes he can,
for example, produce more food. Bad understanding of ecology causes many mistakes. Water is vital for all life processes and more. Water is a key factor in agriculture, fishing, shipping, industry and power generation, but also for nature. Nature provides for countless essential needs (products like fish and oxygen), and services (like cleaning the water) and for which no money is ever charged (Constanza et al., 1998). Many nature products are harvestable. But there are limits. Overexploitation like overfishing the oceans, causes disruption or even destruction of the ‘production unit’, the ecosystem ocean. In short, life on earth and socio-economic development, indeed, our entire civilisation exists because of water. If the signs of the time are not properly read, then things could go badly wrong.

When considering risks you cannot escape a certain degree of pessimism. But there are numerous ways of reducing or even eliminating the risks, provided they are recognised in time and provided there is sufficient political will and public acceptance to be able to take appropriate measures. That measures often only are taken when it is too late is shown, for example, by the water management and civil engineering history of the Netherlands in the 20th century, where decision-making on vital water matters has been dictated by disasters:

- The decision to start work on the Zuiderzee Project in the Central Netherlands, which began with the construction of a barrier dam more than 30 km long (the Afsluitdijk) was made after the disastrous floods of 1916.
- The decision to embark on the Delta Project in the south west of the Netherlands was taken after the disastrous floods of 1953.
- The Rhine and North Sea Action Plans which set out to do something concrete about the deplorable quality of these waters, were only effected due to the disaster with the Sandoz chemical company in Switzerland in 1986.
- It was decided to strengthen the river dykes in the Netherlands, the so called Delta Project for the Major Rivers, after the "near flood" of 1995.

In all these cases the risks had already long been established. In each case there were plans already available: The idea of closing off the Zuiderzee, for example, dates from as long ago as the first half of the 19th century (Stuvel, 1962). In a well argued report, the civil engineer, Van Veen warned in 1944 about the poor state of the dikes in the south west of the Netherlands (Van Veen, 1944, 1945). He recommended that 'immediate steps be taken'. If this were not to be done, he could foresee a disaster of the magnitude which occurred in 1953. His reports however, ended up on a shelf somewhere and he was forbidden from speaking or writing anything further on the subject! Those politically responsible for this decision have never been called to account.......

Decisions for centuries are taken by politicians with vision and responsibility for just a few years. Opportunism is also a not unknown attitude among this professional group. Examples of this type of 'disaster management policy' can be seen all over the world. Think of the catastrophe of the drying up of Lake Aral (Aral Sea) and the area around it as a result of the upstream damming of the Abu Darya and the Syr Darya in Kazakhstan and Uzbekistan. Or the destruction of the mangrove swamps on the coast of Bangladesh, by cultivating these areas. This not only has a disastrous effect on the fertility of the coastal sea but also makes the area more unsafe. In addition, more and more people are settling in the area which could result in more victims in the event of flooding. Building dikes is being considered to reduce the risks. But these give only the appearance of solace. They are predictably insufficient to be able to withstand earthquake waves. The cleared mangrove forests were capable of breaking the force of such waves and therefore played an important part in reducing the risks in that area. Poor education, lack of public information and miscommunication mean that the enormous risks
continue to be hidden. Age, education, religion and cultural differences as well as 'failing to listen' can mean that 'transmitter' and 'receiver' are often not tuned to the same wavelength. The major conclusion so far is that the risks go beyond the physical environment. Risks arising from socio-economic and political considerations are equally as important, but difficult to cover. But there is hope. In a way they are predictable...

RISKS AFFECTING FRESHWATER
The biggest problem now affecting water is the explosive growth in the demand for freshwater world-wide, combined with a decreasing supply per person per year. The trends in each part of the world vary greatly. At the same time, the supply (availability of water per person per year) is declining spectacularly (Fig.2 and 3).

**Fig. 2 and 3. Freshwater demand in the world by sector, and water supply by continent, both in m³ per person per year (Shiklomanov, 1992)**

This explosive growth in demand and the decline in supply is due to various factors. Firstly, the explosive growth in the world population. The average increase in world population between 1960 and 1990 was 75%. This growth was led by Asia with a population increase of 158% in the same period. Growth in Africa in the same period was 135%. Partly as a result of this, the need for food has increased and agriculture has been intensified as a result, particularly with regard to irrigation. In many countries irrigation is the major competitor with household water. Industry also adamantly demands its share. Secondly, with increasing prosperity, the demand for water grows per individual. The desire to raise living standards also increases the demand for water. Thirdly, it is expected that second and third world countries will have to make a major leap forward to catch up. Finally pollution is making water unfit for safe use.

The direct causes of the risks affecting water come from, *floods, draughts, sealevel rise, pollution and over-exploitation.* Most problems can be put down to human intervention or neglect, or have actually been caused as a result of this. The main indirect causes are the explosive population growth and the climate change³.

³ The following messages are taken from the 'Disasters report 1998' of the World Meteorological Organisation (WMO) and the International Red Cross. "As a result of the explosive combination of climate change and overpopulation mankind has to cope in the next decennium with a sequence of super-natural disasters. Harbingers are more frequently occurring hurricanes, floods, and earthquakes in the last period of this millennium." "In 1998 there were more displaced persons as a result of disasters than there were as a result of war or political situations."
The priorities may differ from one area to another and over time. Hence, the first priority in South-Africa now is to manage water scarcity. Water management there is now directed towards demand and supply management and especially the availability of drinking water. In the Rhine Basin the initial focus is on preventing flooding, water quality and shipping. In the Rhine riverbasin is a growing discrepancy between supply and demand, such that priorities could well change in the future.

The risks pertaining to freshwater can be briefly summarised as: too much, too little, and too polluted. Too much suggests a threat to safety in terms of the danger of flooding and excess water. Too little indicates waterscarcity or even shortages and droughts. Too dirty refers to unhygienic situations and pollution. As an overall result there is a tremendous destruction of (vital) ecosystems and there are the problems with biodiversity with a tremendous loss of vital irreplaceable genetic information.

**Too much**

The problems of the Rhine and its tributaries provide an excellent example of the threats and problems affecting an internationally shared river basin after two centuries of intense human impact. So the Rhine is taken as a case (Saeijs et al, 1994). The first question is: are flooding inevitable downstream of the river? The Rhine was headline news in the first two months of 1995 when its water level reached a height which occurs only once a century on average. Floods became a very real threat. In the Netherlands, over 200,000 people, 700,000 pigs, 700,000 cattle and 1,000,000 poultry were evacuated from the endangered polders. As a result of the near flood, the Dutch Minister of Transport, Public Works and Water Management decided that the river dikes should be strengthened over a length of almost 800 kilometres. The estimated cost of this exercise is US$100,000,000. This project, known as the Delta Project for the Major Rivers in the Netherlands, should be completed by the year 2002.

At the end of 1995 water levels in the Rhine where so low that constraints had to be imposed on shipping and water extraction for irrigation. But while the minister's measures respond to

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4 Waterstress index: In trying to quantify freshwater scarcity in a country, researchers generally look to the ratio of water withdrawal to water availability on an annual basis, expressed as a percentage. It is a rough index. In general the higher the percentage, the less room for manoeuvres managing resources.

5 A polder is a typical Dutch landscape feature. In this context it refers to a reclaimed area of land with a peat substrate which forms part of the former flood plain, surrounded by a dike. The ground level of these polders lies 4 to 7 metres below mean river level. This is caused by centuries of "incorrect" drainage of the polders. So the polder is actually a hole in the flood plain, surrounded by a dike.
the need for safety, they do not answer another important question, namely: *were the flooding and the drying-up of the river at the beginning and end of 1995 freak occurrences or are we dealing with a persistent problem?* This question is all the more important in view of the fact that 450 locks, weirs and large dams have been built in the Rhine in order to control the river system (Fig. 5)

![Map of the Rhine basin with Fig. 5 caption]

*Fig. 5. In the last centuries in the Rhine and its tributaries, about 450 dams, weirs, locks and sluices have been built.*

So the real question is: *how is it that a river which is regulated by so many top quality civil engineering works could reach such high and low water levels that people downstream had to flee from the water, or that there could be a serious shortage of water?* My response now is that all these civil engineering works were conceived, designed and constructed as solutions for sectoral and local problems, and that little consideration was given to their impact on other sectors, nor to the impact downstream and upstream. Nor are they managed in a way which is coherent and co-ordinated across the river basin as a whole.

*What are the problems facing the Rhine river basin today?* The Rhine has undergone many major changes over the past 150 years, as a result of which it has lost much of its fragile natural beauty and we have a whole range of serious new problems like floods and drying up. The question now is whether the wet infrastructure of the basin of the Rhine is 'complete'? Most engineers feel it is! Are they correct? If we are referring only to shipping or local interests, perhaps they are right. To obtain a broader answer to the question, we need to ask another question: *why has there been such frequent and large-scale human intervention in the river system?* Over the past 150 years attempts to meet the wishes of all the different parties (like safety, navigability, energy, availability of water) have led to numerous supposed
improvements. Each party was able to present its own arguments for a new series of changes without taking into account other interests or, indeed, the scope and limits of the ecosystems affected. Changes which may be extremely beneficial to one group often turn out to be extremely harmful to others.

Furthermore, the river basin, which was expected to provide everything asked of it, functions as a unit, it is not sectoral or local. The arguments for making changes were usually of a sectoral nature and local in origin. There was - and still is - no sign of any well-founded, integrated consideration of all the impacts or a proper balancing of the consequences of all the interests over the river basin as a whole, neither in relation to new construction, nor in relation to management. This ad hoc approach means that the wet infrastructure is far from complete in my view. But further changes to the river system can only be justified provided they are motivated by a comprehensive vision of sustainable development for the whole Rhine basin. The aspiration of sustainability requires that we start by considering the capacity and limitations of the watersystem (the river basin) rather than the wishes of society. The wishes of society should be adjusted in accordance with the capabilities of the system. Therefore, I would define the problem of the Rhine basin as follows: changes designed to serve sectoral interests have led to the degradation of the river. There is now a need for a costly restoration. Due to human intervention, the Rhine basin is now facing various structural problems. The main ones are related to hydrology, quality, availability and ecosystem problems.

Hydrology. The water storage capacity of the Rhine basin is showing a persistent decline throughout. There are various reasons for this: an ever-increasing urban and rural (agricultural) area is being drained as quickly as possible by sewers and other drainage systems. The result is floods in wet periods and drought in dry periods of the year and a constant decline in groundwater levels. There is 'unlimited' groundwater extraction for irrigation and drinking water. Dewatering during lignite extraction is making the water table fall over thousands of square kilometres of surrounding land. Deforestation by man and by acid rain is reducing the soil's water-retention capacity. The hydrology of the whole river basin is being affected by this. On the one hand the river basin is drying out, while on the other hand an old fashioned drainage policy is pursued under which in times of rainfall flood waves (reinforced by the canalised and shortened rivers) will become increasingly common. This means that even more costly new projects, such as the construction of reservoirs, reinforcement of the dikes and reconstruction of flood plains seem to be needed to improve water distribution and safety.

Quality. Immeasurable quantities of waste materials and toxic substances are dispersed by the system in the river basin, leading to disruption of the ecological balance. In recent decades the situation has improved a lot, but still not enough. Remaining problems are diffuse emissions out of groundwater, and polluted sediments.

Water availability. Water of suitable quality is not always available. The rapid increase in the demand for water and fluctuations in water quality will only aggravate this problem.

Ecosystem problems. As a result of the poor water quality; droughts and floods; the decreasing surface area of the river basin and consequent decline in the variety of types of terrain; fewer and fewer species of plants and animals are able to find suitable habitats. River ecosystems have been disrupted and river banks have deteriorated throughout the river basin. This has been caused by changes in the river's flow, hydrological problems and pollution. The groundwater is deficient in both quality and quantity in many places, with inevitable consequences for the water supply and ecosystems. The seriousness of the ecological impact is shown by river amoeba (Fig 6), indicating that many species are now no longer present while some species are found in excessive quantities.
Too little

The problems associated with water scarcity are taking alarming proportions. What is the nature and scale of the problem? There has been a spectacular increase in the demand for water and a decrease in the water supply per person, per year. The reasons for the rapidly growing demand are: firstly, the explosive growth in the world population; followed by the growing need for food (irrigation) and water for industry. Other factors include increasing prosperity and the desire to raise living standards. As a result of the scarcity (a relative concept) or even shortage (absolute) of water, our planet is risking tens of millions of flood victims and eco-refugees; hundreds of millions of famine and starvation victims; billions of victims of water scarcity and shortage – and, last but not least – humanity as a whole could be affected by conflicts amounting to wars over water that have no precedent in history. Hundred of millions, perhaps a billion, could fall victim. The number is so unimaginable that in one way or another everyone will be affected.

To reflect on these findings, let us start with a proposition. There is sufficient fresh water on earth to meet our needs for today and tomorrow. There is always precipitation (rain, snow or hail). This forms part of the hydrological cycle. Sea water or water on the land evaporates, it is transported through the air and falls elsewhere as rain or snow.

It is estimated that ca. 110,000 km$^3$ of rain falls on land every year. After deducting the evaporation, ca. 45,000 km$^3$ net is left over. This is the average amount of water which humankind and other life forms can sustainable count on. The most credible estimate of how much water humankind needs is about ca 5,000 km$^3$ per year. So there is about nine times as much water available each year on average than is used today by human beings. So what's the problem?

Firstly, there is, of course, the problem that rainfall is not evenly distributed in space and time. What you notice immediately by looking at the worlds precipitation map is how much
rain falls in the areas around the equator and on the oceans and how little falls in North Africa, parts of China, South Africa and America, a very large part of Australia and the polar areas. Lack of water is also often a matter of ignorance among the people and their leaders. In many parts of the world water availability, making it available or unequal access to water sources, are the major problems. A lot of water is made unusable because of its poor quality due to mismanagement. The lack of political interest is sometimes astounding. Competition between users - agriculture, industry and households - can also cause serious problems. It is often simply a matter of political will. Nor should we forget the inhuman and deplorable gap between rich and poor. Too little and too much causes many problems (such as drought and floods) which are closely connected to one another. Many floods are caused by human interventions like deforestation and erosion, as well as the way cities, arable land and wetlands are drained. As a result in times of copious rainfall there are floods because the water cannot be stored in the ground anymore, and in times of lack of rainfall there are no natural water stocks available in the ground or in wetlands. Furthermore, the pollution, depletion and degradation of the environment has a disastrous effect. Desertification and erosion are also signs of mismanagement, and finally, natural ecosystems are being destroyed on a massive scale. All of this has major consequences for humankind, including water-borne diseases, famine, the threat of war over water, genocide, tens of millions of eco-refugees, and people leaving the land for the city and finding themselves condemned to the slums. Strangely enough, there is an amazing indifference on the part of politicians and the public until a disaster occurs.

Too dirty
The quality problems are all too well known: indiscriminate use of surface and groundwater and careless disposal of waste substances, the spread of pathogens; the discharge of organic material, which draws so much oxygen from the water that anaerobic conditions can be created, resulting in widespread mortality and disruption of the living communities. This makes the water dangerous to swim in and other activities such as fisheries can no longer function as they should. Similarly, nutrients, heavy metals and organic micro-pollutants can occur. Waste water is often not treated. It is a problem facing most of the world's population. Polluted water depletes the quantity of water available on an annual basis. In regions with a water scarcity this can be 'the last drop that makes the cup run over'. In riverbasin pollution causes deteriorated rivers and floodplains, and in the lower part of the river hundreds of millions of highly polluted sediments without or with only a few organisms.

Let's have a short look at the history of the Rhine as a case again: In the 1970s the inhabitants of the delta of the Rhine were harshly awoken from their affluent dreams. The Rhine and the Meuse had become open sewers, containing the foulest chemicals imaginable. Ecological communities in and around the river had been virtually wiped out. Each wave of toxins was followed by another. Rotterdam, the largest harbour in the world, was also creating its share of pollution. Industry and households were 'cheerfully' discharging into the rivers, on the principle that "we’re right next to the sea, the water will dilute all the filth and carry it away". However, dilution is no solution to pollution. Now, almost three decades later, there has been considerable improvement. In the Rhine basin expensive clean-up operations have been carried out, at a cost of around $50 billion. Despite these impressive efforts, the end of the clean-up is not yet in sight. The objectives agreed in the Rhine Action Plan, for example, will not be attained within the agreed time. The difficulties were not, in any case, limited to reports of water pollution. In the 1980s the full extent of the pollution of the sediment layer on the water bottom was revealed. The bottoms of the Rotterdam ports were covered with chemical waste. In Hollandsdiep/Haringvliet and Lake Ketel there is an accumulation of all the filth of
the past 50 years from the Rhine and Meuse basins. Here the quantity of polluted sediment is beyond all imagination. It is actually too crazy for words: “Companies were discharging 'for free' and thus 'earning' millions of dollars. The joke, billions and billions of guilders, will have to be dealt with by the society living downstream at a later time. The alternative is that the Dutch people will have to accept forever a dump of toxic waste and a time bomb in one of their most important reserves of fresh water.”

RIVERS AND DAMS
Concerning rivers there are still two items that need special attention; safety and dams. Safety along the rivers is not fully guaranteed and is a constant source of worry. This is partly our own fault in the Rhine case, because we keep on building on the flood plains. After 500 years of raising polders and cities along the banks we have made the room for the river so small that in times of high discharge the water can only rise which leads to increased danger and necessitates constantly raising the dikes. It is also partly due to interventions in the river (normalisation, cutting off bends, shortening (by 25%)! and the construction of 480 locks, dams and reservoirs. This is also partly affected by water management upstream (getting water out of the city and rural areas as quickly as possible, deep drainage for lignite mining and uncoordinated management of locks and weirs, and partly due to deforestation and the destruction of water retention areas upstream (such as the South German Plain between Basel and Karlsruhe).

Special attention is also necessary on dam building. Dams have doubly many advantages. They are build for safety reasons, to store water and waterflow regulation, to avoid downstream floods, for electricity production etc. More than 40,000 big dams are already build in the world and about 300 new dams are build each year, with a lot of problems like environmental and social problems, for example for the Three Gorges dam in China. At least 1,000,000, perhaps 2,000,000 men have to be removed.

In one century nearly all the rivers in the world are under stress as a result of dam building without taking into account the consequences for the riverbasin as a unity nor downstream. It is time to reflect and to ask ourselves as a world community 'what are we doing?' What do we cause to involved people Do we have enough attention for their arguments and do we have enough care for them. And what do we cause to the rivers in the world.. Do we really solve the problems or are we only curing. Are the floods in the Yellow River a freak occurrence or have they a structural cause, like deforestation, erosion and decreasing retention capacity upstream ? Isn’t it wise to tackle the problems of the cause in stead of the problems of the impact? Isn’t that much cheaper on the long term?

RISKS AFFECTING DELTAS AND SEAS
For ages deltas have been the cross-roads of civilisations, and they have become nowadays home for > 40% of mankind. Deltas contain some of worlds most fertile lands, and agricultural productions can be very high. Rivers transport fresh water, nutrients and sediments. River sediments are important to keep track with the sea level rise. In the estuaries fresh riverwater is mixed with salt water from the sea. As a result, delta waters are tremendously fertile, with a high capacity to deal with nutrients and organic materials. However, the cumulative effect of changes in the river's water discharge regime, as a result of upstream interventions, sedimentation and local pollution, have a major impact on the functioning of Deltas and seas. In addition, many Deltas have been subject to large-scale interventions like damming resulting in the loss of an immense natural resilience and production capacity. What are the burning issues (problems) with respect to Deltas and seas at
the end of the 20th century? What are the challenges facing the spatial planners and public administrators of a densely populated delta like the Netherlands? I will briefly outline them below.

First of all, sustainability of deltas is threatened by increasing population pressure, growing need for urban drainage and flood protection, and increasing demand for mobility and transport. The increasing demands of space for human habitats, industrial development, food production and nature, result in complex physical planning in which many interests have to be taken into account (van Urk, 1998).

Sealevel rise imposes another serious threat to delta areas all over the world. Due to the melting of the polar ice caps and glaciers, over the last 17,000 years the sea level has risen by more than 70 cm per century on average. Based on measurements it has been observed that over the last few centuries the rise in sea level was 20 cm a century on average. It is roughly estimated that during the course of those 17,000 years, 38.6 million km³ ice has melted. At present there is still more than 24 million km³ of polar ice and glaciers. Thus, theoretically, a significant rise in the sea level is still possible. The fear is that because of the "greenhouse effect" the temperature will rise by between 1.5°C and 4.5°C and that this could lead to more rapid melting of the polar ice caps and glaciers and so bring about an additional rise in the sea level. This could amount to between 60 and 200 cm per century. This would have a dramatic effect on our country and all the world's deltas. The impact might be tremendous. In Egypt for example 12-15% of the agricultural land will be affected and over 6 million people will be at risk. In China as many as 72 million people and major cities like Shanghai and Tianjin will also be at risk. Apart from a expected sealevel rise, in the Netherlands we are pumping ourselves into the marshy ground. This has resulted in a drop in the ground level by as much as 1.5 metres a century! Furthermore, we are also affected in this country by a tectonic drop of several centimetres a century.

Another major risk affecting deltas is the withdrawal of large amounts of fresh water upstream, resulting in erosion and an increased penetration of salt water. Examples of this can be found in the Mississippi delta and the delta of the Indus, where this resulted in a tremendous capital loss (Constanza et al, 1998). Those responsible for water management downstream in the river course have to deal with the (mis)management of the upper parts of the river, the surface water and groundwater systems.

Because of their nature and position, estuaries and the adjoining sea have a huge production and cleansing capacity. This has largely been lost as a result of the major hydraulic engineering works of the 20th century which were built as the chosen solution to the problem of safety. If the estuaries and rivers would still be intact, then with their natural cleansing capacity they would have been able to deal with the excess of nutrients which come from various diffuse sources such as agriculture, and to turn them into products useful to humankind, such as fish and shellfish.

Freshwater in the deltas is poorly managed. Most of the relatively clean water which falls on the Netherlands as precipitation is discharged as quickly as possible to the sea. It provides no further useful function, because we have closed off our estuaries. In periods of drought, expensive pipelines are used to transport water from the reservoirs or groundwater is extracted, as a result of which the water table falls which in turn causes drying up.

Replenishment of the groundwater is not done on a consistent basis. Safety along the coast is also not fully guaranteed and is a constant source of concern. The better the dikes and dams, the more people are inclined to try to save money on their maintenance. People are unwilling to accept that 100% safety does not exist and that the quality of the dikes and dams has to be improved over time, or even that the dams and dikes may have to be replaced entirely. Reserving space for this is therefore most important. This
means no building on and around the sea walls, trying to create a dynamic and resilient coastline, and taking the nature of the vital processes into account. Make the coast zone multifunctional.

The sea is being over-exploited and polluted: coastal seas such as the North Sea are over-fished by the fishing industry; polluted by shipping and mining and limited not in the least by beach recreation. It is high time that coastal ecology was brought into the picture in a responsible fashion. The oceans too struggle with problems; our aquatic heart is being pummelled by tides of pollution which might side-track its roll in global climate. Biodiversity is also at risk as the greatest variety of animals and plants are found in the oceans.

SOLUTIONS
There are a great many solutions. This subject lies beyond the scope of this article. You are referred to the relevant literature on the subject for an overview, like Tjallingii, 1995, Saeijs and van Berkel, 1995; Saeijs and Korver, 1999).

CONCLUDING REMARKS
• Water is vitally important to all life, as well as fresh, brackish as salt water. Life is dependent on one another. Mankind is an inseparable part of that life system.
• The 21st century will become the urban century. In 2050 80% of mankind live in megacities, and 70% in and around coastal zones, of which 40% in deltas, vulnerable for human activities, because of their dependence on upstream countries, the sea and their qualities.
• Fresh water is becoming increasingly scarce There is no substitute for water. This will have a world wide impact on men and nature.
• It is necessary to abate the risks by tackling the causes of scarcity, pollution and ecosystem deterioration.
• Risks arising from socio-economic and political considerations are at least equally important as risks of physical nature.
• Wide-ranging consideration must be given to the question of how the river basins that concern a country should be managed in the next century
• There is a need for an integrated riverbasin wide approach and for riverbasin solidarity. Integrated water management requires not only a spatial-, but also a temporal component.
• Political decisions about water management issues need a short-term motive, but must be primarily based on a long-term strategy. Long-term strategies must be subjected to explicit political decision-making.
• Most countries in NW Europe waste fresh water. Something must be done about this. Charges must be introduced for taking fresh water from public waters and ground water.
• Trying to achieve consensus in water management (and construction) is not too unrealistic. Investments in management and maintenance at the place where the problems occur must be replaced by investments in structural, process-influencing measures.
• Hydraulic engineering will take place more under water in the next century.
• Safety consciousness (protection against floods) is now reasonably up to standard. This required the occurrence of many disasters. How many disaster will be needed in order to bring ecological consciousness up to the same standard as safety consciousness?
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TRACK 1
SESSION 1

TECHNOLOGICAL RISK – QUANTITATIVE RISK ANALYSIS
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TECHNOLOGICAL RISK QUANTITATIVE RISK ANALYSIS


RISK ASSESSMENT OF DELAYS DURING DEEP WATER PIPE-LAYING

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ABSTRACT
The methodology for minimizing risk of delays during deep water pipe-laying operations has been developed within the framework of Quantitative Risk Assessment, and applied to pipe-laying project in the Gulf of Mexico. It is shown that hazards specific to pipe-laying operations, most of which cannot be considered to be major hazards, contribute more to the overall risk profile of delays than the major or pipe-laying vessel related hazards. The approach offers the insight into the main contributors to risk and the measures that can minimise or control these risks. The management of operations and improved personnel training can significantly reduce the risk of small delays, while the reliable extreme weather forecast reduces the risk of long delays due to vessel and/or pipeline damage.

INTRODUCTION
The construction and installation phases of an offshore project are normally characterised by a very tight project schedule. There are several examples in the offshore industry of project delays and losses caused by failures in the construction and installation phases. The objective here is to assess the probability and the consequences of failures which would cause delays, which is different from so called ‘project risk assessment’ in which scheduling of work and the uncertainties of task duration are investigated. It has been assumed in this study that the uncertainties about task duration have been minimised, and the emphasis is on potential unexpected failures which could cause problems. Therefore, this approach offers the detailed insight into the main contributors to risk of delays, which can then be targeted by remedial measures.

The methodology for the risk assessment of delays has been developed within the framework of Quantitative Risk Assessment (QRA). A QRA-based approach was considered a useful tool to identify high risk or critical operations in pipe-laying process. The methodology is based on the approach that has been used with success for offshore construction projects, and its merits in assessing risks during the design phase of offshore projects have been assessed.

SYSTEM DEFINITION
The main components of the system for which the risk profile is to be evaluated are as follows:

The Semi-Submersible Vessel (SSV) - comprising two floaters and six columns supporting the upper deck structure. The pipelines are to be laid using a J-lay tower. The tower is mounted at the stern of the SSV, which is equipped with a Dynamic Positioning System (DPS).
Pipe barge - which carries typically between 84 and 156 pipe strings depending on the pipe diameter. The pipe strings are stored in to racks which are lifted onto the vessel.

The engineering operations/activities from the pipeline initiation, the actual pipe-lay and pipeline termination are presented in Table 1. The activity applicable to a pipeline is marked by 'x', while 'o' denotes possible abandonment and recovery, and contingency repair procedure.

**Table 1 Pipelines and Related Activities**

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity Description</th>
<th>Sub &amp; Hinge Over</th>
<th>J-Lay</th>
<th>Steel Catenary</th>
<th>Riser Installation</th>
<th>Termination</th>
<th>Pipeline Crossing Installation</th>
<th>Abandonment and Recovery</th>
<th>Contingency Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Production lines 1</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Delivery pipelines 1</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Infield production lines 2</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Export pipelines 2</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Infield water injection lines 2</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HAZARD IDENTIFICATION**
The approach adopted for hazard identification and classification differs from a standard method used in the offshore industry which typically deals with 'major' hazards. The approach in this study is based on the following classification of hazards:

- Vessel related, background, hazards - these hazards are related either to the vessel or the location, and not to pipe laying, for example, passing vessel collision, flooding of compartments, loss of power; etc. Most of these hazards are so called 'major' hazards in the North Sea safety regime.
- Pipe laying hazards are related to pipeline laying operations, for example, J-lay system failure, A&R wire failure, welding quality failure, loss of station keeping, etc. These are operation specific hazards.

**HAZARD ANALYSIS**
The failure frequencies are estimated from historical failure rate data for components, or from statistical data for extreme events such as extreme weather, or from a detailed examination of possible causes of system failure typically carried out by means of fault tree analysis.

The hazard analysis proceeds with analysing the paths of hazard realisation and the corresponding consequences. Since all events have the potential to cause delays, an attempt is made to distinguish between causes of delays that may be as follows:

- Vessel related which are governed by the extent of vessel damage and the required repair time.
- Welding quality related which are related to the time required to pull up the pipe spool, repair the weld and continue pipe lay.
- Delays depending on contingency operations such as pipeline buckle repair; in this category four categories of delays are identified corresponding to the type of damage.
• Delays corresponding to pipeline abandonment and recovery may be governed by the duration of severe weather, warranty surveying and/or legal aspects, etc. Delay categories used in this study were: 6 hours, 1, 2, 5, 10, 15, 30, 60, 90, and 180 days. An event tree approach has been utilised to explore all the possible paths along which an event can propagate to unwanted consequences, and therefore an event has the potential to lead to different combination of delay days.

RISK ANALYSIS
Risk summation results in the risk profile for all pipeline laying operations on per project basis, while the fatality risks are evaluated on an annual basis to facilitate comparison with other offshore activities. The following risk measures have been evaluated:

• Risk of delays in terms of the expected number of delay days (which is a sum of products of outcome frequency and the corresponding delay over all outcomes and events)
• Frequency of categories of delays
• Risk of fatalities in terms of the Fatal Accident Rate (FAR), and the Individual Risk Per Annum (IRPA).

The total expected number of delay days is 2.74 days per project, and its breakdown by delay categories is presented in Figure 1.

Figure 1  Risk profile in terms of expected number of delay days

Five delay categories (up to 10 delay days) account for 78.7% of the risk of delays; in particular hurricanes contribute 24.8%, pipeline repairs due to installation failures 22.1%, tropical storms 19.9%, and upending ramp failure contributes 12.4%. In general, the result indicate that in this pipeline laying operations, the delays are governed by hazards related to pipe-laying operations and not by the ‘major’ hazards. Out of ‘major’ hazards, the most dominant is the ‘extreme weather’, i.e. hurricanes.
The cumulative frequency $F$ of $N$ or more delay days (F-NDD curve) compared against the risk acceptability criteria, indicated that risk of one day delay is slightly above the maximum tolerable criterion, while most of the risk of delays longer than one day is within the tolerable zone, Figure 2.

**Figure 2**  
*F-NDD curves before and after risk reduction*

**CONCLUSIONS**

The following can be concluded from this study:

1. The methodology can successfully be applied to minimise the risk of delays during deep water pipe-laying operations.
2. The risk of delays for this pipeline laying operations is within the acceptability criteria.

In general, four areas for risk management and possible further improvements are: avoidance of pipeline buckles by monitoring pipeline sag bend geometry, pipeline stresses and vessel movement, minimisation of welding faults, improvement in pipe spool upending, and more reliable hurricane forecast. This means that most of the operational risk can be retained by suitable management controls, while only a small portion of rare events such as extreme weather may need to be transferred.

4. Risk of fatalities is comparable to other vessel operations.
FRACTURE/CORROSION STATISTICS IN GAS INDUSTRY 1980-1999

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Full paper see page: 898
Environmental risk management has become a main issue in general and in particular where certain materials such as chemicals, oils, gases and other hazardous waste are involved. This includes the pipeline industry where the transfer of materials such as oils and gases are concerned. The pipeline accident risk is a key point in the environmental communication of the pipeline company, because it represents a social and competitive issue. The idea is to find statistical correlation between boundary conditions of an existing pipeline and the boundary conditions recorded in sites where a previous accident took place. The pipeline system, divided into proper sections, will be classified by a statistical vulnerability coefficient (not by a subjective score). A statistical risk rating for the pipeline is carried through previous accident history.

The adoption of effective preventive measures by pipeline managers (pro-active policy of risk management) is supported by the reliability and objectiveness of this methodology. The data are gathered in a GIS, integrated with Access 97 database and SPSS applications.

INTRODUCTION.

Failures of pipelines conveying dangerous substances can pose major risks. Release of flammable and toxic material can be the initiating events of accidents with catastrophic effects; public tolerance to environmental pollution and accidents is now decreasing and liabilities for the owner following a release are potentially enormous.

As pipeline crude transportation systems are considered a major hazard, the creation of a computerised system for the evaluation of pipeline risk has been considered:

- to define acceptable levels of risk related to a pipeline system;
- to prioritise maintenance operations spending for the periodical budgeting process;
- to reduce the insurance rates;
- to establish a proactive strategy respectful of interests claimed by the different stakeholders.

A Risk Management System allows a company to identify needs, to analyse cost vs benefit of various choices, to establish an operating discipline, to measure all the processes and continuously improve all aspects of its operation. Costs may be reduced by spending in ways that reap the largest benefits, namely, increasing the reliability of the pipeline: spending to prevent service interruptions and damages to the environment is an integral part of optimising pipeline costs.

REVIEW OF THE RAP PROJECT.

The objective of the RAP project are the following:

- risk evaluation of a pipeline network, transporting crude oil, by a statistical methodology;
- fast monitoring of oil spillages;
• costs vs benefit analysis in the pipeline management.

In this paper the attention is directed to the statistical methodology and the cost benefit analysis.

**DATA COLLECTED.**

The causes of oil spillage are divided by CONCAWE (the oil companies European organization for environment, health and safety) into five main categories.

<table>
<thead>
<tr>
<th>Causes</th>
<th>CONCAWE STATISTICS 1971-1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third party activity</td>
<td>33%</td>
</tr>
<tr>
<td>Corrosion</td>
<td>30%</td>
</tr>
<tr>
<td>Mechanical failure</td>
<td>25%</td>
</tr>
<tr>
<td>Operation failure</td>
<td>7%</td>
</tr>
<tr>
<td>Natural hazard</td>
<td>4%</td>
</tr>
</tbody>
</table>

The main idea is to find the relationship between the causes of accident and the pipeline boundary conditions by a statistical analysis. Once this relationship has been found, a statistical classification of the pipeline risk can be done (for example through discriminant analysis).

Boundary condition are data (variables) describing the route of the pipe:

- Hydrogeological data (logically linked to corrosion and natural hazard failures): hydrology, groundwater depth, lithology, soil permeability, ...
- Anthropic data (linked to third party activity failures): land use, population density, street crossing, railways crossing, ...;
- Mechanical data (linked to mechanical and operational failures): operating pressure, diameter, wall thickness, burial depth, ...

A 90 Km pipeline transporting crude oil, has been selected as the case study: it has been divided in segment of 50m of length and, for each segment, the listed data retrieved. The segment length has been chosen according to the quality (scale) of available information. Also data on external corrosion (number of external defects for segment) are available.

Data about previous accident history have been retrieved: as the Italian data about oil pipeline aren't sufficient for statistical analysis, data about accidents on pipeline transporting liquid substances have been collected through the Department of Transport (USA). Assumption has been made that European and USA pipelines are comparable.

Five database, one for each causes of spillage, has been built: for each accident, the variables logically linked to the accident cause have been collected. The principal causes of spillages, corrosion, third party and mechanical, have been analysed: with the analysis of variance the following significant results were found.

**STATISTICAL ANALYSIS.**

**Corrosion accident.** Lower permeability soils, sewer and street crossing are significantly more dangerous:

<table>
<thead>
<tr>
<th>Variable</th>
<th>F</th>
<th>Sig.</th>
<th>Df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Permeability</td>
<td>33.197</td>
<td>.000</td>
<td>5</td>
</tr>
<tr>
<td>Lithology</td>
<td>39.420</td>
<td>.000</td>
<td>3</td>
</tr>
<tr>
<td>Sewer crossing</td>
<td>3.461</td>
<td>.063</td>
<td>1</td>
</tr>
<tr>
<td>Street crossing</td>
<td>3.074</td>
<td>.080</td>
<td>1</td>
</tr>
</tbody>
</table>
Third party accident. Urban Area, small pipe diameter, railways and street crossing are significantly dangerous.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$F$</th>
<th>Sig.</th>
<th>$Df$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>194,751</td>
<td>.000</td>
<td>2964</td>
</tr>
<tr>
<td>Land Use</td>
<td>12,405</td>
<td>.000</td>
<td>2964</td>
</tr>
<tr>
<td>Railway crossing</td>
<td>78,003</td>
<td>.000</td>
<td>2964</td>
</tr>
<tr>
<td>Street crossing</td>
<td>32,263</td>
<td>.000</td>
<td>2964</td>
</tr>
</tbody>
</table>

Mechanical accident. Large pipe diameter and high operating pressure are significantly dangerous.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$F$</th>
<th>Sig.</th>
<th>$Df$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>13,974</td>
<td>.000</td>
<td>1</td>
</tr>
<tr>
<td>Operating Pressure</td>
<td>41,904</td>
<td>.000</td>
<td>1</td>
</tr>
</tbody>
</table>

Statistical Model Evaluation.

Discriminant procedures were used to identify a linear combination of quantitative predictor variables (or discriminant functions) that best characterizes the difference between the group risk or no risk of accident. These are the results on the training set.

<table>
<thead>
<tr>
<th>Accident Model</th>
<th>Successfully classified cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion</td>
<td>74%</td>
</tr>
<tr>
<td>Third party</td>
<td>93%</td>
</tr>
<tr>
<td>Mechanical</td>
<td>68%</td>
</tr>
</tbody>
</table>

Several tests with logistic regression were done, but the improvement wasn’t significant. Run with neural network will be available as soon as possible.

DISCRIMINANT ANALYSIS.

An intercomparison among different statistical methods has been conducted to solve the problem of discriminant analysis. The techniques compared in terms of forecasting power are: linear discriminant analysis, logistic regression, and neural networks.

Linear discriminant analysis is described here. Differences among $g$ groups (previously defined, with $g \geq 2$) with $n$ observations, can be analysed with linear discriminant analysis: $p$ independent variables are combined in one or more linear equation called discriminant functions:

$$d_{ij} = \alpha_0 + \alpha_1 x_{1j} + \alpha_2 x_{2j} + \ldots + \alpha_p x_{pj} \quad i = 1, 2, \ldots, \min(p, g-1); j = 1, 2, \ldots, n$$

In the present study, the analysis is on a dichotomous dependent variable (risk / no risk), so just one discriminant function is computed. The discriminant function coefficients are computed to maximize the difference among groups. Observations are classified to each group by the $d_{ij}$, the discriminant scores, computed for the analysed observations. To evaluate statistical significance, the $F$ test and the $p$-value are used.

Four fundamental hypothesis are assumed in linear discriminant analysis:

1. each observation is independent;
2. each variable should have a multivariate distribution;
3. the spreads of variances should be equal across group;
4. covariances should be equal across groups.

In practical application these hypothesis aren’t fully satisfied, but the discriminant analysis results may be used for a qualitative analysis.
CLASSIFICATION OF THE PIPELINE.
The statistical models developed on the training set are applied to the classification of the pipeline segment. The output is the discriminant score for each segment of the pipeline, for each model (corrosion, third party interference, mechanical). The results are displayed in a GIS (red segment risk; green segment no risk).

COST-BENEFIT ANALYSIS
The aim of the economic model in issue was to find a decisional criteria in base to which orienting the investments on the most suitable action for spill prevention. The first step has been to create a decisional tree that evidences all the possible actions in order to contrast the risk of loss from a pipeline. In the second place has been searched all the costs of the possible actions. Finally a software that could calculate the total cost of a group of actions, has been created. The benefit of every group of actions has been estimated as increment of the time of accident return or in the same way, as lowering of accident probability.

Before whichever action of loss prevention, a pipeline is characterised from a determined time of accident return and from a number of segment more to risk than others. The carried out actions on the pipeline make that the number of segment to risk decreases. The efficiency of prevention interventions can be estimated like the ratio of number of segment to risk after the action to number of segment initially to risk. The decrement of the risk is calculated as the product between the efficiency of the action and the probability of initial accident. This benefit can be quantified economically as a reduction of the amount to set aside annually in order to

make forehead to a soil remendation and other cost related to an oil spill. Infact, if the time between two accident event becomes higher, the number of years on which the total cost of spill must be shared becomes more and so the annually amount set aside will be smaller. The most suitable group of actions is that which leads the highest efficiency, the biggest risk decrement and consequently the biggest saving.

DECISION SUPPORT SYSTEM.
All the previous data and algorithms are gathered in the GIS ArcView 3.1; the GIS allows the pipeline managers to explore, visualize, query, and analyze the data geographically. Statistical algorithms are based on SPSS 8.0 software, the tabular data are stored in a Microsoft Access 97 database, the cost-benefit model is an Excel spreadsheet.

ACKNOWLEDGEMENTS
The authors wish to thank the Department of Transport, DOT, USA, for providing part of the data used in the statistical analysis.

BIBLIOGRAPHY


Web Resources.
http://www.safepipeline.com
R.A.P. project web site: information and results about the project; a discussion group and a mailing list are available.
http://www.concawe.be/
http://ops.dot.gov/
http://www.undergroundinfo.com/
The safety of the transport of dangerous goods is guaranteed by technical regulations that are up-to-dated periodically. A first step towards a revision of regulations, based on technical and scientific analysis, consists of a comparative evaluation of the associated risk to different substances involved in reliable accident scenarios.

In the present work the most remarkable phenomena, from the point of view of consequences, have been considered for accidents related to transport by road of flammable and toxic/flammable liquefied gases.

Consequence models developed by TNO and EPA for the calculation of physical effects (heat radiation, overpressure and vapour cloud dispersion) resulting from specific accident scenarios (catastrophic failure of the receptacle and failure due to sharp object with the production of a hole) have been analysed. Subsequently, using dose-effect correlation models (probit function), it has been evaluated the damage to people caused by release of thermal energy, by peak of overpressure and by toxic concentration in air.

On the basis of results the efficacy of the models has been evaluated and a comparative analysis has been possible for the considered flammable and toxic/flammable gases in relationship to the damage to people. Besides, the correlation between dangerousness of the substance (intrinsic risk), chemical-physical behaviour and effects on people have been examined, in relation to the hypothesised accident scenarios. The probability that a human being suffers a damage in presence of a field of pressure or heat radiation or toxic concentration was examined as well using probit-function.

Finally a comparative model is proposed; this model allows to calculate a risk index for each of substance examined by an appropriate composition of probit function.
The paper describes an algorithm to predict gas-petroleum and chemical technology facilities operation risk parameters in relation to human beings. The main attention have been paid to an algorithm for calculating potential risk values and isolines when flammable and toxic substances transfer over the environment in event of industrial accidents, for example, BLEVE or toxic gas blowouts. The accident scenarios, dimensions and configuration of negative effect zones depend greatly on the environment parameters (the atmosphere, topographical conditions, etc.) of the region considered. Potential risk is interpreted in the paper as a quantitative measure of possibility of occurring human being lethality at a given space point caused by an accident at the facility considered. Peculiarities of estimating potential risk values are that the great dependence of toxic or flammable clouds transfer parameters on the atmosphere conditions even for a concrete accident blowout do not allow to predict simply the lethality probability corresponding to the effect dose at the territory point considered. While the toxic or flammable cloud transferring under wind influence the effect dose values can vary from zero to an extreme level at each territory point passed. Hence in the same manner there varies the lethality probability at the point. With due account of this the potential risk at the concrete point is evaluated as a mathematical expectation of the lethality probability to be a function of random arguments. These arguments are a blowout mass rate, wind velocity and direction, and the atmosphere stability. Consequently the paper also describes defining the frequency distribution function of the arguments to calculate potential risk. The potential risk isolines and real human beings distribution over the territory near analyzed hazardous facility during exposure period enables to assess individual and collective risks.
The development of technosphere causes the rise both in living standards and danger to the population and the natural environment. Therefore the strategy of steady development should take into account the contradictory consequences of the economic development. A rational strategy needs appropriate mathematical means to base on; the theory of safety is not an exception from the rule.

A hazard implies the probability of causing harm. More or less degree of hazard is inherent to any kind of activity. The hazard degree is characterized by risk, which is estimated using quantitative indices.

The principle elements forming the system of risk analysis are the source of hazard, the hazardous event, harmful and injurious factors, the object of impact, and the damage.

Potentially hazardous establishments (such as those of nuclear energetics, chemical industry, explosive- and fire-hazardous units, hydrotechnical constructions), conditions of professional activity, territory of the region and its living conditions: all may be viewed as a source of hazard. Conditions of activity (living) include possible natural hazardous phenomena and technogene emergency situations, frequency of their occurrences, degree of the environment pollution.

The potential of a hazard realizes in occurrence of a hazardous event. By hazardous we’ll mean such an event (accident, catastrophe, extreme natural phenomena) which leads to formation of harmful and injurious factors to the population, establishments of technosphere and natural environment. If the source of the hazard is considered to be in activity (living) conditions, the risk in that case takes place even in the absence of hazardous events because of the probability of an unfavourable effect as a result of natural environment harmful factors (in case of pollution).

By harmful and injurious (later on referred to as hazardous) factors are meant radiation (radiation fields), mechanical (percussions, earthquakes), ballistic (fragmentation fields), thermal (heat stream), electromagnetic (lightning discharges) and other impacts; redundant concentrations of radioactive matters, carcinogens and toxicants, which emerge after realization of a hazardous event or characterize the living conditions. Hazardous factors cause people’s health worsening, technosphere establishments damage and destruction, ecosphere state worsening. Also hazardous factors lead people to diseases (wounds) and death in the very process of influence (if these people happened to occur in the field of influence). Hazardous factors cause discussed effect with certain probability. Therefore the probability of these effects is characterized by risk as well. For example, radiational risk of ionizing irradiation is determined by dose and probability of unwanted consequences (genetic damages or death in the rest of life of radiationally induced cancer).
By the object of impact of the factors which form in a realization of a hazardous event or accompanying certain living conditions are meant an individual human (individual risk), a potentially hazardous establishment’s personnel (joint risk), the population of the region or country as a whole, technosphere establishments (risk of their destruction; it also may cause another hazardous event according to the “dominoes” effect), the country economy and the environment (ecological risk).

By damage is meant hazardous factors’ impact on an individual’s health, the country economy and the environment condition (an impact on the country economy and the environment lead in the long run to the decrease of living standards of individual people). Direct damage and indirect consequences are distinguished, the latter being considered at higher level systems than the object of direct impact of hazardous factors (a region, an economy branch or the country economy as a whole). The main kinds of consequences are political (decline of trust in State institutions), economical (direct and indirect damage from the loss of the establishment, financial loss because of broken contracts), social (payment of compensations of victims), ecological (the environment pollution) and other.

A threat of causing damage to an object takes place in case of its presence in the field of hazardous factors of the source of danger.

Example 1. The source of danger: a nuclear power station. Hazardous event: a radiational failure. Hazardous factors: spread of radiational matters, which form an ionizing irradiation field. The object of impact: the population of the territory adjacent to the nuclear power station and the natural environment. The damage: diseases and deaths of people in the rest of their lives of radiationally induced cancer, radiational pollution of the territory.


Usually the risk concept is understood as a probability of occurrence of rare events. And risk is often understood as a probability of occurrence of these events in a fixed time interval (usually a year). Probability is identified with the risk measure (index) convenient for risk comparison of the same object (subject) in various situations or different objects (subjects) in typical functional conditions.

Risk is also usually connected with the amount of loss resulted from the hazardous event expressed either naturally (such as the number of injured and killed, dimensions of the area influenced by hazardous factors) or in terms of value.

So, independent variables used to estimate risk are time and damage; risk estimation (prediction) is based on frequency of realizations of hazardous event and average harm it causes.

Mathematical means needed to solve above problems follow herein after.
Hazardous events realization distribution by amount of harm is calculated with the help of probabilistic method using mathematical models for rare events; for rather frequent events it is calculated with the help of a statistical method using hazardous event realization statistics for available observation period.

Analysis of various hazardous events’ consequences show that a moderate description of harm distribution is approachable using such widely known distributions as truncated normal, logarithmically normal, Veybulle's distribution and some others.

Logarithmically normal distribution is preferred in cases when more precise “tail” approximation of hazardous event realization distribution by harm (the field of large harm) is needed. A random positive number is the argument of the logarithmically normal distribution, its logarithm being distributed by the normal rule. Determination of the arguments of the distribution by available statistics (hazardous event realizations) should use the values of their logarithms. Adequacy of the theoretical model to statistical data is practically independent of logarithm’s base.

Harm distribution is properly described by Veybulle's law with parameters of dimensions and form when a large dispersion specific to some hazardous events' consequences is present. In particular, Veybulle's distribution describes the number of injured and killed on account of explosions and fires in Russia.

The indices of a hazardous event realization frequency used for their prediction are probability and mathematical expectancy of the number of event realizations per year. Mathematical means used for calculation of these indices are based on examination of the hazardous event realization over a period of time.

The indices for rare events realizations for an object and a system of objects are the same. Both are calculated using the hazardous event realization intensity, the latter being the most general index of a hazardous event frequency. Given the knowledge of intensity dynamics one can predict the frequency in cases when hazardous event realization stream is not stationary.

So, hazardous event risk estimation requires the knowledge of both the realization intensity as a function of time and the harm distribution. The above-mentioned characteristics can be obtained using probabilistic and statistical methods. The risk index of a hazardous event realization for independent objects is the probability of at least one realization; for a higher level systems (higher than independent objects which are directly impacted on by harmful and injurious factors) it’s the mathematical expectancy of a hazardous event harm per year.
CHEMICAL RISK ASSESSMENT BASED ON THE FRAMEWORK OF BASIN-WIDE ECOLOGICAL MODELING AND THE ECOTOXICOLOGICAL INDEX

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Key Words: Ecotoxicological risk assessment, Linear alkylbenzene sulfonates, Fate analysis, Second order moment approach, probability of lethality

ABSTRACT
This paper presents a method for estimating the ecotoxicological risk of toxic chemicals in terms of probability of an organism’s lethality coupled with fate analysis and analysis of the dose-response relationship. The ecotoxicological index is defined as the probability of the magnitude of the exposure concentration of the chemicals in an aqueous environment being more than the organism’s resistance to the chemicals. This approach is based on a second order moment approach used in statistical reliability analysis. Linear alkylbenzene sulfonates (LAS) were used as test chemicals in this study. By comparing the estimated probability and the quotient, the potential risks of the test chemicals were characterized.

1. INTRODUCTION
In hazard assessment or in screening levels of risk analysis of chemicals, the quotient method is generally employed and it provides a useful measure, although it seems to be a simplistic approach (OECD 1989). The measure is the ratio of the predicted environmental concentration (PEC) to the predicted no effect concentration (PNEC) of chemicals. If this ratio is less than 1, it only tells us that the environmental impact due to this chemical is less than the target value of the endpoint. As this value becomes large, the concern increases. In short, the quotient method is a comparison of representative values in each data set. However, the sensitivity of an organism to a chemical varies according to the dose. The concentrations of chemicals in the environment also vary in spatially and temporally. Consequently, a method that utilizes such data sets is required.

In this paper, we present as analytical framework for evaluating ecotoxicological risk in terms of the probability that takes into account the variability of the organism’s resistance and the chemical concentration in the environment. The analytical framework is based on a second moment method that is used in statistical reliability analysis.
2. PROBABILISTIC ECOTOXICOLOGICAL RISK ASSESSMENT METHOD

The analytical process used in this study is shown in Fig. 1. First, variability in the organism's resistance to the chemicals' toxicity is calculated from the dose-response relationship. Second, assuming a lognormal probability distribution for the observed dose-response relationship, the means and standard deviations are estimated. Third, the variability in spatial and temporal distributions of environmental concentration is calculated from the mathematical fate, and the means and standard deviations are also estimated. Finally, the probability of lethality is calculated from the obtained statistical values by using a second moment method.

![Diagram of Probabilistic risk assessment](image)

**2.1 Variability in an organism’s resistance to a chemicals’ toxicity**

Using the results of toxicity tests, variability in resistance to a chemical is estimated by the Probit function in relation to the endpoint of acute lethality (e.g., LC₅₀). This function assumes that the distribution of individual sensitivities with respect to log dose is normal; a probit is the normal equivalent deviate plus five. The probit function is:

\[
\text{probit}(\pi t) = \frac{\log d_i - \mu}{\sigma} = \frac{1}{\sigma} \log d_i - \frac{\mu}{\sigma}
\]

where \( \pi t \) is the proportion response, \( d_i \) is dose or exposure concentration, and \( \mu \) and \( \sigma \) are the mean and standard deviation with anormal distribution, respectively. In short, the dose-response relationship can be expressed as a linear function in relation to the logarithm of dose (\( d_i \)). Fitting to the test results and the variability is characterized as the mean and standard deviation of the probability distribution.
2.2 Variability of contamination concentration in aqueous environments
In estimating the environmental concentration of LAS, a mathematical model water runoff model and chemical fate model were solved simultaneously (Tokai et al., 1998) is used. The concept of these models is followings.

2.2.1 Watershed model
A water runoff model is a mesh-typed model that explains vertical and horizontal water movements with the spatial resolution of 500 meters square. The concept and the governing equations are shown in Fig.2. Land is divided vertically into four layers, and horizontal and infiltration flow rates are calculated from these governing equations.

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**Fig.2 Multi-Layer runoff model**

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**Fig.3 Multimedia fate model of chemicals**
2.2.2 Chemical Fate Model
This model is constructed using the multimedia compartment model. This model consists of seven compartments (air, soil, ground water, river water, river sediment, paddy field and sediment) and incorporates a variety of transport phenomena associated with pollutant transport such as advection, diffusion, deposition and runoff. Using daily weather data, the concentration in each compartment was calculated. Fig. 3 shows a conceptual diagram of a chemical fate model.

2.3 Approach to calculating probability of an organism’s lethality
Based on statistical reliability analysis, Jacobs et al. (1991) presented an approach for estimating the probability of an organism’s lethality that assumes the environmental system can resist an environmental load due to the introduction of a hazardous substance. The basic concepts are as follows; the organisms will not survive the environmental contamination if its resistance is less than the contaminant concentration. Assuming that the contaminant’s concentration in the environment can be modeled as a random variable \( C \) and resistance of the organism can also be modeled as a random variable \( R \), then an organism will not survive the environmental contamination if its resistance is less than the contaminant’s concentration. That is,

\[
R < C \quad (2)
\]

The probability that the organism will not survive the environmental contamination is defined as the probability that the organism’s resistance is less than the contaminant’s concentration. Mathematically, this expressed as

\[
P(R < C) = \sum_{c} P(R < C | C = c) P(C = c) \quad (3)
\]

where \( P(R < C) \) is defined as the probability that the organism will not survive. If \( F_R(c) \) and \( f_C(c) \) present the distribution of resistance to contamination and the distribution of contamination concentration, respectively, and \( R \) and \( C \) are independent statistical and continuous variates, the probability of the organism’s lethality is defined as

\[
P(R < C) = \int F_R(c) f_C(c) dc \quad (4)
\]

where \( F_R(c) \) is the cumulative distribution of \( f_R(c) \) evaluated at \( C \). Typically, \( F_R(c) \) represents the dose-response relationship.

Finally, we obtain equation (5). The details of the mathematical formulation have been explained in a previous paper (Jacobs et al, 1991). Consequently, if we obtain the mean (\( \mu \)) and the variance (\( \sigma^2 \)) of each data set, the probability of the organism’s lethality can be estimated.

\[
P(R < C) = 1 - \phi \left( \frac{\mu_R - \mu_C}{\sigma_R \sqrt{2\pi}} \right) \quad (5)
\]

where \( \phi(\cdot) = \) the standard normal distribution function.
3. CASE STUDY

3.1 Test chemicals and test area
The test chemicals were linear alkylbenzene sulfonates (LAS). The test watershed was Y river in A prefecture of Japan. The area of the test watershed is 120 square km. The period of model simulation was the year of 1991 with daily time step resolution. The environmental parameters of LAS and the geographical features of the test area are explained in previous papers (Hori, 1996, Masuda, 1998, and Tokai, 1997).

3.2 Test organisms
LAS is an industrial chemical that has been extensively investigated with regard to its toxicity. In this study, considering the impact of aquatic organisms, we selected the following four species: Orange killifish (Oryzias latipes), Carp (Cyprinus carpio), Ayu (Plecoglossus altivelis) and Minami-numaebi (N. denticulata). All of these are common species used as test organisms in Japan. This small number of species was considered sufficient for the purpose of this study, because each of these species has a very different level of resistance to LAS.

Fig. 4 Distribution of the organism's resistance and the environmental concentration for LAS

4. RESULTS AND DISCUSSION

4.1 Deviation in resistance to and concentration of LAS
The results of the distribution of the organism's resistances to LAS and the calculated environmental concentrations of LAS are shown in Fig. 4. The distribution of the organism resistance was obtained from the dose-response relationship of acute toxicity test results. The spatial distribution of the LAS concentration in water was calculated using the mathematical model explained in section 2.2. Here, since we only show the results for illustrative purpose, the calculated results that correspond to the winter season are used. Because the degradation rate constant is small, a relatively higher concentration of LAS obtained. On the other hand, the range of the mortality among test organisms is different clearly. So, it showed that the
sensitivity of an organism to a chemical varies according to the dose. Actually, the range of environmental concentrations is larger than the organism resistance and the probability of lethality can be calculated if the mean and variance of toxicity are introduced.

4.2 The probability of lethality of the organisms due to LAS

Table 1 shows the probability of lethality and the ratio lethality of each aquatic organism to the concentration of LAS in river water in winter. Actually, the difference of probability of lethality to test organisms reflect the their resistance to LAS and the variation of environmental concentration of LAS. Comparing this value with the quotient, these evaluated results are different. Consequently, considering the variability of these data, the potential risk to test organism under the exposure of LAS was found and quantified.

<table>
<thead>
<tr>
<th>Organism</th>
<th>P(R&lt;C)</th>
<th>( \mu_{LC_{50}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange killifish</td>
<td>9.4x10^{-3}</td>
<td>5.2x10^{-3}</td>
</tr>
<tr>
<td>Ayu</td>
<td>1.9x10^{-1}</td>
<td>1.2x10^{-1}</td>
</tr>
<tr>
<td>Carp</td>
<td>9.3x10^{-3}</td>
<td>1.8x10^{-2}</td>
</tr>
<tr>
<td>Minani-numaebi</td>
<td>1.5x10^{-2}</td>
<td>4.1x10^{-3}</td>
</tr>
</tbody>
</table>

Fig.5 Amplification of \( P(R<C) \) from upstream to downstream for the four species

4.3 Spatial distribution of the probability

Fig.5 shows the spatial distribution of ecotoxicological index expressed as the value of \( P(R<C) \), with special attention to parts of the watershed. There is significant variability in the susceptibilities of each target organism to LAS. Ayu was the most sensitive of organisms tested in this study. The different susceptibilities of the organisms are clearly shown. The amplification of the ecotoxicological risk from upstream to downstream corresponding to the urbanization that accompanies the increase in LAS consumption is clearly quantified. Based
on this analytical framework, alternatives that reduce the risk of LAS exposure can be quantitatively evaluated in terms of the probability of lethality of organisms as a next step.

5. ACKNOWLEDGMENTS
This work has been supported by CREST (Core Research for Evolutional Science and Technology) of the Japan Science and Technology Corporation (JST).

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DEALING WITH THIRD-PARTY RISK AROUND A MAJOR AIRPORT

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ABSTRACT
Air traffic not only poses problems for the population living in the vicinity of airports but also may significantly affect the operations of third parties. The objectives of the current investigation were to describe the current situation at major airports in the Netherlands and the documented growth of the third-party problems, both with respect to the airport and the community. The study was conducted at 31 airports in the Netherlands, with special emphasis on 11 major airports.

The technical specifications for them in 2011-2012 were documented and their impact on the environment and community was evaluated. These problems were exacerbated by the rapid growth of the population in the Netherlands and the associated growth of the airport and residential areas.

The results of the investigation indicated that the airports have different approaches to the problem of third-party risk. Some airports have developed comprehensive strategies to mitigate these risks, while others have adopted a more reactive approach.

In the current phase of the study, an effort was made to identify the principal documents that describe the third-party risk at each airport and the actions taken to address these risks. These documents were used as a basis for the development of a comprehensive framework for managing third-party risk.

The framework was developed to help airports in the Netherlands address the challenges associated with third-party risk and to facilitate the implementation of effective strategies for risk management.

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A. ACKNOWLEDGMENTS
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A. REFERENCES


DEALING WITH THIRD PARTY RISK AROUND A MAJOR AIRPORT

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ABSTRACT
Air traffic not only poses a risk for passengers and crew but also for the population living around the nodes in the air traffic network: the airfields. To manage these third party risks effectively it is necessary to know the extent. The methodology to quantify these risks has developed rapidly over the last decade. Several methods are now available. The results of these calculations for Schiphol airport show that meaningful information, relevant for decision making can be generated.

INTRODUCTION
The international airport of the Netherlands, Schiphol, is situated some 10 km south-west of Amsterdam. The airport was founded in 1916, with the first regular service, by KLM - Royal Dutch Airlines, taking place in 1920. On the occasion of the Olympic Games in Amsterdam in 1928, the airfield was equipped with tarmac runways. In the Second World War the airport was completely destroyed. Rebuilding started after the war.

From the beginning the number of movements at the airport has grown by an average rate of about 5.3% per year. The growth was only temporarily retarded during periods such as the second world war and the gulf crises. In 1990 there were approximately 200000 movements. The current expectation is that in 2015 600000 movements will take place at Schiphol. The continued growth led to considerable problems, both with respect to the capacity of the airport and to the environment. These problems were enhanced by the rapid growth of the population of the Netherlands and the associated growth of the cities around Schiphol and Amsterdam, in particular. The capacity on the ground and in the air is limited and further growth is only possible through a substantial expansion of the road and rail network, and the airway system.

At least one more runway will also be needed, maybe not so much for capacity but to decrease the noise nuisance.

In the preparatory phase of the decision making for the necessary extensions of the airport a planning document, PASO [1] was issued in which two joint aims were defined for the future development of Schiphol airport:

- Schiphol should develop into a mainport and
- The quality of the environment around the airport should improve.

One of the preferred ways of doing this implied the construction of a fifth runway.

To support the process that would lead to a decision on whether to expand the airport and how, studies were made on such aspects as the environmental consequences of several alternatives. One of these was ‘third party risk’. In the Environmental Impact Assessment the risk for the surrounding population, also called third party risk, for the alternatives selected in PASO, was considered. The awareness of these risks was enhanced by the crash of a Boeing 747 in the Bijlmermeer in 1992. In this accident 39 people of the ground lost their lives together with four people on the plane.
THE GENERAL POLICY

In a densely populated and highly industrialised country as the Netherlands it is virtually impossible to reduce industry-imposed third party risks to zero. Therefore authorities and industry had to face the task of how to control these risks effectively. A significant fact in this respect is the considerable political pressure exerted by public opinion about these hazards. The Dutch authorities have adopted a policy for risk management in environmental matters based on quantified techniques. This policy is described in the annex ‘Premises for Risk Management’ [2] to the National Environmental Policy document. In Dutch environmental policy two quantities used to measure risk have been defined: Individual risk (IR)- the chance that a person staying at a fixed location permanently is killed as a result of an accident in the hazard source, expressed in units per year, and societal risk (GR)- the chance that in a single accident in the hazard source a certain number of victims is exceeded. It is expressed as the relationship between the number of people killed and the chance per year that this number is exceeded.

For each of these criteria, limits have been set. The limits for individual risk are limit values under the law and thus cannot be exceeded. The limits for societal risk are set as guidelines. Currently the limit for individual risk is set to $10^{-6}$ yr$^{-1}$ for new situations for fixed facilities and for transport. For existing situations a tenfold risk is accepted. For societal risks advisory limits are set at $F = 10^{-3} N^{-2}$ for fixed facilities and at $F = 10^{-2} N^{-2}$ per kilometre route for transport. [3] For Schiphol a special regime has been established in which the limit value for individual risk is set at ..., societal risk is currently not being used as a basis for decisionmaking and a derived risk parameter has been introduced which is the sum of the values of individual risk at each house (GGR) inside the $10^{-5}$ and the $10^{-6}$ IR-contours. It has been decided, that after 2003, when the fifth runway is operational GGR may not be larger than it was in 1990.

RISK ANALYSIS

To be able to confront the risks of an airfield with existing policies it is necessary to have methods to analyse and quantify these risks. It is necessary to calculate the probability of an accident in the vicinity of an airfield and the extent of the consequences. Several systems have been developed, which differ in details. These differences result from judgements on what can sensibly be derived form the available information. All the available models in essence are based on statistical evaluation of past accidents. No models are currently available based on pure causality arguments.

The models used in studies around Schiphol are ‘Aircrash’, developed by Technica [4,5,6,7], ‘RAND’ [8], and the NLR model [9,10]. The methods used to calculate third party risk around airports consist of three main elements:

- the probability of an aircraft having an accident in the vicinity of the airport,
- the geographical distribution of the accidents,
- the extent of the crash area and the fraction of people potentially affected that will actually be killed.

For each of these entities a method or model has to be given by which it can be determined.
THE PROBABILITY OF AN ACCIDENT

The accident rates can be calculated from historical data in a relatively straightforward manner by dividing the number of accidents by the corresponding number movements. To achieve an adequate statistical basis, data from more than a single airport must be used. However, since large differences exist between accident rates for different world regions, different categories of aircraft, different types of operation, etc., the accident rate calculated from a large data set cannot simply be applied to a particular airport. The accident rate must be calculated from a selection of the data considered representative for the airport under investigation in order to arrive at results specific to that airport. Because the results of the risk analysis must be reasonably reliable, the desire to apply many selection criteria to make the calculated accident rate airport specific must be carefully balanced with the need to have enough data remaining from a statistical point of view. The collection of a large database for accident and aircraft movements is thus an important prerequisite. The NLR database, for example, was compiled from 13 sources. The resulting database contains some 25,000 relevant accidents. For the Schiphol analysis NLR selected data pertaining to Western-Europe, North-America and New Zealand, airports with more than 150000 movements per year, airplanes heavier than 5700kg and accidents within 26 km of the airport during the period 1976 and 1989. The estimates of the accident probability differ between the various methods as is indicated in table 1, were the accident ratio is given for 1990.

<table>
<thead>
<tr>
<th>Table 1: Accident ratios (1990)</th>
<th></th>
<th>Table 2: Normalised damage areas for a crash of a Boeing 767 in a built-up area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Landing</td>
<td>Take-off</td>
</tr>
<tr>
<td>TECHNICA (1990)</td>
<td>0.22</td>
<td>0.57</td>
</tr>
<tr>
<td>TECHNICA (1991)</td>
<td>0.21</td>
<td>0.37</td>
</tr>
<tr>
<td>NLR (1993)</td>
<td>0.65</td>
<td>0.43</td>
</tr>
<tr>
<td>RAND (1995)</td>
<td>0.32</td>
<td>0.95</td>
</tr>
<tr>
<td>NLR (1998)</td>
<td>0.55</td>
<td>0.36</td>
</tr>
</tbody>
</table>

THE ACCIDENT LOCATION PROBABILITY

The accident location probability model defines the local probability of an accident provided an accident occurs; in other words, if an accident occurs, this model describes the probability that the accident aircraft will end up at a particular location. The way accident locations are distributed throughout the area before and after the runway, considered not to be time-dependent, allows the distribution of accident locations in the past to be used to predict the distribution of accident locations in the future. The three methods mentioned before use different philosophies here. In the NATS model it is assumed that an airfield or a runway is the focal point of airplane movements. Most planes will successfully land or take off, but some will miss the runway and crash. The pattern of crashes is considered independent of the standard routes because once a plane is in an accident situation it is unlikely that it will follow these routes. In the AIRCRASH model the geographical distribution of accidents is built from the routes. It is assumed that the location of the accident has a relationship with the location were the accident started to happen. The nature of this relationship differs for landings and take-offs.
In the NLR model the location model also depends on the routes. Here no assumptions are made with respect to the mechanisms involved in a crash. The locations are related to the routes on a purely statistical basis.

THE ACCIDENT CONSEQUENCE MODEL
The consequences of an accident in terms of the size of the accident area and the lethality of the effects inside the accident area are defined in the consequence model. The only consequences considered in third party risk analysis for airports are fatal injuries to people on the ground as a direct result of an aircraft accident. Many aircraft-, impact-, and environment-related factors determine the accident consequences. All models consider the influence of the mass of the airplane and the obstacles in the terrain. AIRCRASH considers the influence of the position (impact angle and attitude) of the aircraft, other models do not. Lethality is estimated by dividing the number of casualties by either the number of people present or by the number of inhabitants. The estimate of the lethality is associated with the estimate of the size of the crash area. In table 2 a comparison of the combined estimate is given as a normalised area: i.e. the crash area multiplied by the lethality, for a Boeing 767 in a built-up area [8]. It can be seen that these estimates differ significantly.

RISK RESULTS AND CONTEXT
The methodology developed by NLR and the results of the studies were published as part of the series of reports constituting the Environmental Impact Assessment [9,10]. Calculations were made for Schiphol as it was in 1990 and an extensive series of potential alternative developments for the future. Figure 2 gives the individual risk contours for the proposed extension of Schiphol with a fifth runway and a traffic volume of 430,000 movements per year. Figure 3 gives the societal risk F-N curve. Although the methodology used in these studies differed from Technica's, the NLR reports largely confirmed the results of the earlier studies. The expected development of some relevant risk parameters [11,12,13] can be seen in Table 3, where the numbers of people exposed to risks of a certain level are given for 1990, (the reference year), 1997, 1998, 2003, the year in which the construction of the fifth runway should be completed and 2015, the time horizon of the plan. The numbers there can be seen to rise significantly; it can also be seen that considerable numbers of people are exposed to risks above a level considered acceptable for chemical installations in the Netherlands. The results also show that, under the original assumption of 430,000 movements in 2015, the joint aims for the development of Schiphol airport were being met through the construction of a fifth runway which allows a more favourable distribution of the traffic over the area around Schiphol. The actual development of traffic volumes at Schiphol suggests that a volume of around 600,000 in 2020 is more likely.

<table>
<thead>
<tr>
<th>Tabel 3: Development of some risk parameters at Schiphol airport</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGR &gt; 10^5</td>
</tr>
<tr>
<td>GGR &gt; 10^6</td>
</tr>
<tr>
<td>Inhabitants</td>
</tr>
<tr>
<td>Inhabitants</td>
</tr>
</tbody>
</table>
CONCLUSION
The third party risks around a major airfield are significant. As airports attract housing developments, a serious land-use planning problem is posed. The quantification of these risks is feasible and helps the decision-making process. However there are still major methodological issues to be further developed.

DISCLAIMER
Any opinions expressed in this paper are those of the authors and do not necessarily reflect the position of RIVM or the NLR.

REFERENCES
USING COLOURED PETRI NETS FOR IMPROVING INTRINSIC SAFE DESIGN IN A NEW TRANSPORTATION SYSTEM

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Despite of the numerous existing risk analysis methods, risk management in complex systems, at a conceptual stage, is still arduous. In the Swissmetro project, a high-speed underground train planned for interurban linking in Switzerland, this challenge is somewhat enhanced because of the technical innovations and the ensuing hazards involved. Due to both novelty and conceptual stage of the project, it is presently difficult to quantify occurrence of failure or breakdowns in the future Swissmetro system.

In order to promote an intrinsic safe design, a method of accident scenarios modelling has been developed during Swissmetro main study. This method, based on Coloured Petri Nets CPN, is discussed in this paper. Petri nets are mathematical tools, which allow dynamic simulation of parallel and concurrent systems with time constraints. The known atomic elements (actors, events, cause to consequence relationships) of the accident process are translated in the Petri net formalism. Simulation of the net structure allows exploration of all possible accident scenarios and outcomes.

Using Petri nets for accident simulation has several advantages. Complex logical or temporal relationships may be taken into account during the simulation. Hence, the model allows representation of accident dynamics more complex than classical methods such as FTA, or ETA. Moreover, using the model for tunnel accident modelling shows consistent results in comparison with current principles of tunnel safety management.

INTRODUCTION

Swissmetro project.

Swissmetro is a project of a new public transportation system for interurban linking in Switzerland. Because of geographic and surface occupation constraints, Swissmetro vehicles will travel underground. In order to decrease the aerodynamic drag in the tunnels, ambient pressure will be reduced significantly (partial vacuum 8-25 kPa). To ensure high performances (max. speed 500 km/h), the vehicles will be propelled and guided without friction by linear motors and a magnetic levitation system (MAGLEV).

Preliminary safety study.

In first instance, Swissmetro may be compared to a subway or a train in tunnel. Although oversimplified, such comparison allows the use of previous accident data as a basis for future accident modelling. Moreover, for both public and authorities Swissmetro is perceived, by analogy, as a train.

Using literature, databases and contacts, a review of rail tunnel accidents has been conducted as a part of the National Research Program PNR 41 (transport and environment). Several well-documented cases amongst the 176 accidents collected have been investigated with the STEP (Sequentially Timed Events Plotting) method [1]. As a result of this investigation, a short collection of main actors, events and cause-to-consequence relationships for tunnel accidents has been established.

Towards accident modelling.

A systematic risk analysis of Swissmetro is at present difficult, due to both novelty and
conceptual stage of the project. On the one hand, a quick iterative process is needed to handle the frequent design changes during the project. On the other hand, an extensive systematic approach is required to anticipate ‘new’ risks. The latest is of great concern because, disregarding technical innovations, Swissmetro presents a unique combination of hazards, usually encountered in either ground or air transportation. To fulfil the Swissmetro safety study specific requirements, the use of Petri nets for accident scenario modelling has been investigated.

**Petri nets**

Petri nets are mathematical tools, which allow dynamic simulation of parallel and concurrent systems with time constraints. Defined by C.A. Petri in 1962, Petri nets are now used for dynamics systems specification, description and verification in a wide range of applications.

Formally, vectors and matrices define Petri nets [2]. Less formally, a Petri net may be described graphically by a set of places \( P(P_1...P_m) \), a set of transitions \( T(T_1...T_n) \), a valuation function \( W \) (illustrated with arrows) and an initial marking \( M_0 \). The marking describes the number and type of tokens occupying places, defines a state of the net.

**Occurrence graph.** An occurrence graph is a structure describing all distinct states (all distinct markings) reachable during the net simulation. Distinct markings are illustrated as nodes in the occurrence graph. Final states of the simulation are called death nodes. The size of the occurrence graph may be expressed using its number of nodes or death nodes.

**Coloured Petri nets.** Contrarily to classical Petri nets, tokens may be differentiated in Coloured Petri Nets (CPNs). Colouring tokens is achieved by giving more or less complex properties to tokens (numeric values, string of characters...).

**Interest in safety.** Petri nets, as tools for discrete events simulation, are of utmost interest in safety. Dynamic changes in the Petri nets are induced by transition firing during simulation. Firing of one or several transitions changes the net marking or, in other terms, induces a discrete change of state. Thus, dynamic proprieties of Petri net such as parallel firing, successive firing or firing of concurrent transitions may be used to simulate complex events sequences.

**ACCIDENT SCENARIO MODELLING**

**Principle.** Prior to modelling, a preliminary identification of accident relevant elements is required. This preliminary step may be achieved using classical accident investigation methods such as FTA or STEP analysis. In this study a multilinear accident theoretical model has been used as reference. This model describes an accident process as a set of parallel event sequences, assuming a linear sequence for each accident actor.

Relevant actors, events and causal relationships are translated into the Petri net formalism (see Fig. 2). During simulation, one of the possible events successions is processed. Rather than investigating each accident scenario separately, the overall simulation results are examined through the occurrence graph, which summarises all successions of states allowed...
by the net structure. Interesting states may be investigated systematically, using software built-in functions for occurrence graph nodes search.

![Figure 2 - Modeling overall process](image)

**Software.** The model has been implemented on Design CPN (version 3.04, for Unix) software.

**Actors description.** Each actor in the accident process is linked to a place in the net structure. The current situation or action undertaken is displayed by the tokens occupying an actor place (see Fig. 3). Each token is coloured with a couple of values: A qualitative argument (the actor's action or situation) and a quantitative argument (the time of occurrence of the event).

**Events description.** Occurrence of an event in the accident process is simulated by a transition firing. Tokens' colour may be modified by a transition firing, but their number remains unchanged. When a colour change occurs, both qualitative and quantitative arguments are updated (see Fig. 3).

**Logic relationships.** Cause to consequences relationships between events are translated in the Petri nets formalism with the help of concurrent transitions, parallel transitions, arcs expressions and guards expressions. These two latest tools may be used to define complex enabling rules for transitions.

**Time.** Time logic may be simulated by two different ways. Using a timed Petri net, such as Design CPN, event duration may be taken into account directly in the simulation process. Without using a timed simulation, time logic may also be processed using tokens’ colour. This second method is more complex and leads to larger occurrence graphs (but fuzzy time logic may be taken into account) [3].

**APPLICATION**
Using similarities with subways or train in tunnel, a scenario modelling has been conducted for the Swissmetro. Events, actors and cause-to-consequence relationships pointed out during the previous STEP analysis have been used to built the basic Petri net structure. Despite the reduced number of events taken into account (about 20), simulation of the net structure leads
to a large number of distinct scenarios, which may be roughly estimated with the number of death nodes.

Modifying parameters, such as initial marking (initial accident conditions), time logic or cause to consequences relationships, while keeping the same number of events, leads to occurrence graph size ranging from $10^4$ to $5 \times 10^4$ nodes. Changing simulation parameters is of prime interest in order to study distinct accident conditions, such as changes in safety rules or safety equipment. Meanwhile, both net structure and simulation conditions must be chosen carefully in order to avoid occurrence graph outgrowing.

As an example, Table I shows the occurrence graph’s size resulting of a Petri net simulation according to two modes of time logic.

<table>
<thead>
<tr>
<th>Simulation conditions</th>
<th>Num. of nodes</th>
<th>Num. of death nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>all events, fuzzy time</td>
<td>48,975</td>
<td>6533</td>
</tr>
<tr>
<td>all events, fixed time</td>
<td>1,857</td>
<td>361</td>
</tr>
</tbody>
</table>

Table I: Occurrence graph size for two simulations

Occurrence graph size gives merely an overall view of the simulation outcome. Accident scenarios have been interpreted in a more elaborate way, using Design CPN built-in functions to examine occurrence graph nodes. Indeed, accident scenarios have been classified regarding the hazardous level of the final states reached. The results obtained are coherent regarding both previous tunnel accidents and tunnel safety principles [4].

CONCLUDING REMARKS
This paper present a methodology for accident scenarios modelling with coloured Petri nets. The net structure developed allows simulation of discrete events occurrence in a multilinear process. Amongst other advantages, coloured Petri nets allow use of complex time and cause-to-consequences logic. For example, logical relationships used in either FTA or either ETA may be processed in the same net structure.

Contrarily to the state space method, in which every state must be known previous to simulation, the model discussed uses basic accident elements to generate a set of accessible states.

Petri nets are generic tools, which may be used to model a wide range of dynamic systems. The model briefly discussed in this paper focuses mainly on events qualitative or timed description. Meanwhile, in return for a change in the net structure, probabilistic data may be processed in the model in a similar way as time data. It must be stressed however, that an optimum must be chosen between the net size and the level of detail simulated. Increasing any one of them leads to more complex simulation, which may growths out of hands.

REFERENCES
ASSESSING AND COMPARING RISKS OF TRANSPORTATION, MANIPULATION AND STORAGE OF HAZARDOUS SUBSTANCES: A CASE STUDY IN ITALY

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INTRODUCTION
The adoption of an effective safety management system, as well as the land use and the emergency planning, and the information to people on risk to which they are exposed are probably the main tools for managing accidental risks in industrial areas. Notwithstanding the individual responsibility of each authority involved in the decision process, a risk assessment is required in order to identify what can happen and how likely it can be.

For this reason, regulations that came into force in the late '80s in the EU countries require the maker of the plant at risk to prepare, upgrade and notify to the public authorities a safety study, including in some cases a complete Quantitative Risk Assessment (QRA). On the contrary, a QRA is not required to the maker or to the public authorities for transportation of dangerous goods, although about one third of the accidental release of hazardous chemicals happens during such an activity. Evaluating whether the transport of dangerous goods can be neglected in land use planning and/or in preparing emergency response in industrial areas is the main question for the public authorities responsible for it, particularly considering the vulnerability of the areas which can be involved in the accidental event.

In this paper, individual death risks from fixed plants and from transportation of dangerous goods were compared in order to assess if the latter would really be negligible. The study, as part of a wider one, was performed with the aim of preparing emergency plan and managing risk through land use planning in a populated industrial area in the north of Italy. Here a petrochemical factory, a refinery, a paper mill, a couple of commercial plant storing Liquefied Petroleum Gases (LPG) and other smaller industrial activities are located. Results will briefly be discussed in this paper emphasising the methodological issues rather than the numerical risk estimates.

The QRA of at-risk plant
The study was performed in the industrial area of Mantova, which, on a 7-km2 surface, hosts many industrial activities. Among them, 36 plants (18 in the refinery, 15 in the petrochemical factory, two LPG commercial storage plants and a railway station) can be identified as major industrial risk sources, for them the manufacturers have to notify a safety study to the public authorities. The railway station is not a proper industrial plant, but it was so considered for its activity in moving rail-tanks containing hazardous materials, even though without any manipulation of the tanks content. The presence of passengers, the quantity of hazardous materials moved daily, the duration of the rail-tank stay and its location in a residential area have suggested its inclusion in the study as a plant at risk.

Assessing accidental risk of an industrial area by safety studies prepared by the makers for each plant requires the identification of some general principles and the adoption of some assumptions. In fact, the intrinsic subjectivity of QRA, either in the identification of accidental events and the estimate of their consequences, and the lack of a general standard
rule for compiling the reports do not allow to integrate the different studies performed in the area. In particular, rules are needed for making comparable the type of initiating events, the physical characteristics and/or the dimensions of release sources, the duration of releases, the meteorological conditions in which dispersion is simulated, etc. For example, some rules adopted in this study state that:

- a pipe failure is always simulated by two different releases with efflux hole’s surfaces respectively of 25% and 100% of the whole section of the pipe. When such an approach was not used in the safety report and only one release was considered, the probability of the second event was arbitrarily assumed with a value equal to one hundred time smaller than the reported one. The failure of safety devices was always considered in this study even if neglected in the safety reports and its probability arbitrarily assumed with a value equal to $10^{-2}$ events/year (e/y). For example the possibility of an accidental opening on a 2 inches hose recorded in the safety report by a release of 60 seconds from a 13 mm diameter hole with probability of $2.2 \times 10^{-2}$ e/y is simulated in the study by two different events:

- the first one, including two releases, both from a 50 mm diameter opening, with probabilities of $2 \times 10^{-4}$ e/y and $2 \times 10^{-6}$ e/y and duration of 60 and 1800 seconds respectively;
- the second one, including two releases, both from a 13 mm diameter opening, with probabilities of $2.2 \times 10^{-2}$ e/y and $2.2 \times 10^{-4}$ e/y and duration of 60 and 1800 seconds respectively;

- according to Italian Regulations (IR), a Boiling Liquid Vapour Expanding Explosion (BLEVE) and a fireball of a LPG storage tank were assumed as impossible for insulated or mounded tanks. On the contrary, this study estimates the probability of an Unconfined Vapour Cloud Explosion (UVCE) containing less than a ton of substance in its flammable limits, regardless the IR suggestions which are considered not conservative enough;

- the adverse effects are exclusively referred to human health and estimated only for people living near the risk source. Consequently, damages to the workers operating in the area were neglected as well as damages to the environment and buildings.

By this approach 208 accidental events, involving the release of 13 hazardous chemicals, have been identified as a reasonable representation of the major industrial risks in the area. These events include tank failures (overfilling 12%, leaks 16%, PSV 3.8% and tank rupture 2%) and line failures (leaks 49%, hose pipe 19%). Releases of toxic chemicals prevail in the former, while the flammable ones prevail in the latter. In particular, the selected accidental scenarios regard the releases of LPG (48%), gasoline (11%), benzene (11%), styrene (8%), acrylonitrile (5%), phenol (4%), methane (4%), acetone (4%), ethylene (3%), n-pentane (2%), other (3%). Benzene and acrylonitrile, known as carcinogens, were considered in this study only for their flammable and toxicological properties.

Consequences have been quantified as fatality probability by the probit methods suggested in the literature in case of exposure to thermal radiation, overpressure and inhalation of toxic chemicals (1). In each case, the estimate uses a simplified exposure pathway foreseeing an individual fixed in the considered site for the whole duration of the accident, and a standard human being, weighting 70 kg, in good health conditions and wearing not-protective clothes. Results show that about one fourth of the selected accidental events, which likelihood ranks
between $10^{-3}$ e/y and $10^{-5}$ e/y, could affect people living surrounding the industrial installations. In terms of risk it means that the highest individual death risk is about $10^{-7}$ e/y, while the societal risk estimated in the area with a probability of about $10^{-4}$ e/y with 10 or more victims and of about $10^{-5}$ e/y with 50 or more victims. These results show that, while an individual death risk greater than $10^{-3}$ e/y can be expected just in few and very limited residential areas, an individual death risk greater than $10^{-4}$ e/y should instead be expected in significantly larger residential areas (2).

**QRA OF DANGEROUS GOODS TRANSPORTATION**

The industrial area of Mantova is located in one of the main industrial areas of North-Italy, it is crossed by an important highway connecting Italy to the north-east of Europe and it is a node of the main river network for waterway transport too. Consequently, it is interested by a heavy traffic of dangerous substances, which only partially concern the industrial activities sited in the area. In this situation, quantifying and identifying the dangerous goods circulating in the area needed two different surveys:

- the first one, in order to point out the origin or the destination sites of the dangerous chemicals and the carriers used for their transportation (truck, wagon, tank barge and pipeline), by submission of a self-administered questionnaire to the managers of the local industrial activities;
- the second one, in order to identify the hazardous goods transit ing in the area by pointing out, on a sample basis, the ADR codes on the trucks circulating on the roadways.

Results show that more than a hundred substances classified for their dangerousness, most of which transported by road vehicles, were identified as circulating in the area. About one third of the substances is carried by road and a tenth by rail and tank barge. Pipelines, used by the refinery and the petrochemical factory for their supply of raw materials, are the most used transportation means carrying more than a half of the overall quantity of the dangerous substances circulating there. More than 6.4 million of tons of hazardous materials, about three fourth of which are petroleum products, were estimated to reach or leave yearly the industrial area of Mantova. Assuming five days per week as working time for transport by road, rail and tank barge; and seven days per week as working time for pipelines, more than 10 - 12 ktons per day of dangerous substances are estimated to transit by mobile vehicles or pipelines in the considered industrial area. Excluding oil products, about 1 Mtons per year of substances, classified as flammable, toxic and in some cases carcinogenic, was expected to transit in the area. With reference to the local industrial activities, about two third of these substances are produced or used as solvents, raw materials or intermediates in the plants of the petrochemical factory. The remaining one third includes solvents, paints and those other products classified for their dangerousness and used in the minor industrial activities of the area. However, due to the difficulties in carrying out the projected surveys, these data underestimate the quantity of dangerous chemicals annually circulating in the area.

From a theoretical point of view, the accidental release of a dangerous chemical can arise from the involvement of the carrier in an accident or from a mechanical failure. Consequently, even initially neglecting mechanical failure, in order to assess risk from transportation of dangerous goods, the accident probability and the release probability, given the accident, need to be known. With reference to road transport, for example, estimating the accident probability may result very hard because the overall number of vehicles circulating in an area in a given period can be hardly known and in any case it depends on:
- road class (two-lane, divided or undivided multilane, freeway, one-way street, etc.);
- area type (urban or rural);
- traffic volume density expressed in terms of trucks volume and average daily volume data;
- meteorological conditions during the accidental events.

In addition, the release probability of the transported dangerous goods is strictly related to the type of accident and its actual occurrence. For example, studies on this topic related to road transport showed that in single-vehicle non-collision accidents, like overturned or run-off, the release probability is about 30 and 10 times higher than in collisions between truck and fixed objects or moving vehicles respectively (3, 4).

Historical data sets on releases of dangerous goods during their railway transport suggest two main causes of spillage: puncture or damage to the tank-wagon due to collision or derailment and failure or maloperation of the tank-wagon equipment. Data sets on railway accidents involving the release of dangerous goods are very scarce and the UK-HSC (5) summarised from 1959 to 1989 thirteen events where at least one toxic, flammable or explosive substance was released. Thus, these events seem to be very rare and, although the statistical data set could be incomplete, it allows estimating a lower release probability for rail transport compared with the road one; even though, given the accident, a higher release probability should be expected for the rail transport. This is why in this study, historical data from international literature have been used to estimate release probability.

Examining the quantity of dangerous substances being moved, pipelines and road transport are the main risk sources for people living in the area. On the contrary, due to the vulnerability of the area, transport by road and rail is the source of potentially higher health adverse effects for people living there. In order to compare such risks with their likelihood, the release probability for the mentioned transport ways was estimated.

With reference to road traffic, records of road accidents occurred in the last six years in the limited area of the Municipality of Mantova were used for estimating either the trucks probability of being involved in a road accident and the release probability, given the accident, for trucks carrying dangerous goods. By this way, a release probability of $3.8 \times 10^3$ releases/year (r/y) can be estimated for the whole area (6).

With reference to rail transport, data from international literature have been used when no specific knowledge is available for the area. In particular, release frequency of $14 \times 10^{-9}$ and $2.5 \times 10^{-9}$ occurrences per vehicle/km are reported for thick walled tankers from The Netherlands (TNO, 1983) and the United Kingdom (HSC, 1991) respectively (7). In this study, considering an average travel length of 10 km/wagon, a release probability ranging between $1.2 \times 10^{-4}$ and $6.4 \times 10^{-4}$ e/y can be estimated. A supplementary study on UK data (8) for thin walled (about 6 mm) wagon suggests a puncture frequency of $6.3 \times 10^8$ occurrences per wagon/km. Then, a release probability of $2.9 \times 10^{-3}$ r/y can be estimated for the whole area.

With reference to the transport of dangerous goods by pipeline, about 10 km of the lines supplying the refinery with crude oil and the petrochemical factory with other raw materials pass across the considered area. The release probability for pipelines closely depends on their diameter and other constructive characteristics, on the management system of the company,
on the environment conditions, and so on. Also in this case, specific data are not available and suggestions can be obtained from literature (9) referred to specific substances (i.e. oil products) or to specific countries, like USA where regulations require the registration of pipelines accidental events. As to the different information sources, a release probability ranking between $4 \cdot 10^{-3}$ and $5.6 \cdot 10^{-3}$ r/y can be estimated for the whole area.

The release probability for tank barge transport is very difficult to estimate and affected by a large uncertainty because of the influence of many local variables in using this kind of vehicle. Studies on this topic suggest that releases arise from leaks in about 90% of the cases and the remaining 10% from ruptures. For this reason the use of no-specific data are not recommended and, considering also the low quantity of dangerous goods moved by this carrier in the area, releases from tank barge were neglected.

CONCLUSIONS
In order to compare risks from the fixed plants with those from the transport of dangerous goods an overall picture should be drawn with respect to the likelihood of the accidental events and the consequences attributable to them. In particular the results of the studied area show that the probabilities of accidental events in fixed installations are exponentially distributed with a median of $1.6 \cdot 10^{-4}$ e/y and a 90% central range from $1 \cdot 10^{-5}$ e/y to $6.2 \cdot 10^{-2}$ e/y (2). The release probabilities for road and rail transport, estimated respectively equal to $3.8 \cdot 10^{-3}$ r/y and $2.9 \cdot 10^{-3}$ r/y, as well as the release probability from pipelines, ranging between $4 \cdot 10^{-3}$ e/y and $5.6 \cdot 10^{-3}$ e/y, are closely comparable with those from fixed installations. In addition, a peculiarity of risk from transportation of dangerous goods is the undefined location of the accidental event and consequently a potentially higher severity of the damages for people. In fact, local historical data sets show that about 67% of road accidents, involving at least one truck, occur in inhabited areas and most of the railway passes across the town. Moreover, the railway station is located in a populated area; it is an important shunting site of wagons containing hazardous substances moved to or from the petrochemical factory or the refinery. These results suggest that, at least in terms of the likelihood of accidental events, neglecting the transport of hazardous materials in planning land use and the emergency response could strongly bias the decision process. In addition this finding may be confirmed by looking at the expected consequences for people and environment.

ACKNOWLEDGEMENTS:
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DERAILMENT PROVISIONS FOR A HIGH-SPEED TRAIN LINK IN THE NETHERLANDS

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ABSTRACT

Dutch State plans the construction of a high-speed train link from Amsterdam to the Belgian border (direction Antwerp, Brussels, Paris). For coping with safety Dutch State works according to an Integral Safety Plan. The plan contains a general approach and also quantitative risk criteria. The quantitative risk criteria reflect the individual risk of the risk bearers in the system (the passengers, personnel, passers-by, suicidals, emergency personnel) as well as the societal risk (related to the number of accidents and their seriousness).

This paper covers the efforts to comply with the risk criteria for the accident type derailment and describes the rationale for implementing derailment provisions. Derailment provisions make sure that a derailed train follows the track, does not turn over, and does not encounter fixed points.

INTRODUCTION

In the Netherlands, safety of rail traffic has always been a public issue. Dutch State has decided to build a high-speed train link from Amsterdam to the Belgian border, connecting to Antwerp, Brussels and Paris (further called: HSL-South), and is fully aware of the risks involved. Therefore, Dutch State decided to prepare a safety plan [1], describing how to implement safety and giving quantitative risk criteria.

The Integral Safety Team of the Project Organisation HSL-South implements this Integral Safety Plan. The method this team applies is in short:
- Identify the relevant incident types: collision, derailment, fire in tunnel, etc.
- Determine the risk level of the current design.
- Formulate measures to decrease the risk.
- Assess measures for decreasing the risk and propose accepted ones to management.

As an example how this approach works in practice, this paper describes the process that eventually ended in advising the implementation of derailment provisions for the incident type derailment.

THE INTEGRAL SAFETY PLAN

The Integral Safety Plan describes the approach of Dutch State for coping with the risks in the HSL-South. It covers qualitative and quantitative criteria and the organisational framework. In this paper we will concentrate on the quantitative criteria.

The quantitative risk criteria cover individual risk of the risk bearers in the system (see Table 1). These numbers are based on the following assumptions:
- Risk stand still. The risks of new infrastructure shall not be higher than the current risk level achieved. E.g., the individual risk of passengers is 75% of the individual risk currently achieved in the Netherlands.
- The risk level demanded shall be realistic.
Also Dutch State formulated criteria for societal risk. Societal risk embraces the concept of risk aversion: the higher the number of fatalities in a single accident, the larger the societal shock. This means that large accidents should have more severe criteria than small ones. The formula for the maximum expected frequency of an accident with N or more casualties for the HSL-South is:

$$\text{Maximum frequency [1/year]} = \frac{1}{(\text{Number of casualties})^2}$$

For assessing the incident types individually, the Integral Safety Team divided the total allocated risk over the incident types. This leads for example to the risk criteria for the societal risk for the incident type derailment for the high-speed line between Rotterdam and the Belgian border as given in Table 2 [2].

Table 2. Criteria for societal risk for the incident type derailment for the HSL-South between Rotterdam and the Belgian border

<table>
<thead>
<tr>
<th>N - number of casualties</th>
<th>≥1</th>
<th>≥10</th>
<th>≥100</th>
<th>≥1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>f [1/year]</td>
<td>4.0·10^{-2}</td>
<td>1.0·10^{-3}</td>
<td>1.0·10^{-3}</td>
<td>1.0·10^{-7}</td>
</tr>
</tbody>
</table>

Note that the allocation of the risk to a certain incident type is totally at the discretion of the project organisation. Dutch State is only interested in realising the top-level safety objectives. This means that whenever the Integral Safety Team concludes that the risk criteria for a certain incident type are not met, it can either decide to improve the system or to redistribute the risk, as long as the top level safety objectives are met.

Derailment is one of the major accident types in train traffic. When train speeds become higher, as is the case in high speed train links, the number of people injured and killed in a derailment accident can increase significantly, and therefore its associated risk. It is therefore utterly plausible that we need extra provision to meet the criterion of risk stand still.

**ANALYSIS OF THE INCIDENT TYPE DERAILEMENT**

The Integral Safety Team extensively studied the incident type derailment. It appeared that the risk criteria for the societal risk are very hard to meet.

The Integral Safety Team advised to take the following additional measures (not complete):

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2 The individual risk for passengers is derived from a fatality rate of 1.5·10^{-10}/passenger.km.

3 ALARP = As Low As Reasonably Practical.
- Detection of derailment in the train, combined with an automatic braking action after detection, combined with a braking action of possible approaching trains on the adjacent track.
- Detection of various defects in the train, e.g., hot box and vibration detection.
- Derailment provisions on the high-speed sections of the HSL-South.

The management of the project organisation easily accepted the first two measures, these are relatively straightforward and are probably state of the art by the time the HSL-South is ready for operation.

Figure 1 (left) shows the fN-curve of the incident type derailment after implementation of the safety measures, except derailment protection for the southern part of the HSL-South, from Rotterdam to the Belgian border [3].

![fN-curves of the incident type derailment for the HSL-South between Rotterdam and the Belgian border. Left: without derailment provisions, right: with derailment provisions.](image)

The analysis shows that with derailment provisions – with an effectivity of 99%, i.e. 99% of the derailed trains do not leave the track\(^4\) – the risk becomes acceptable, see Figure 1 (right).

However, derailment provisions are very expensive and have never before been used to the extent the Integral Safety Team proposes. Also, it is not necessarily so that derailment provisions that work for normal train traffic are effective in the case of high-speed train traffic. The next paragraph addresses these analyses.

**ANALYSIS OF DERAILMENT PROVISIONS**

The design characteristics of derailment provisions include: the position of the provisions (inside or outside of the track), their height, their distance to the rails, their stiffness, etc..

The analyses show that the most important features of the derailment provisions are their distance to the rail, since this directly influences the speed with which the train hits it, and their stiffness, since this directly influences the forces on the wheel and the train. Table 3 shows the results of calculations [4, 5].

\(^4\) Without derailment provisions, an estimated 92% of the derailed trains do not leave the track.
Table 3. Forces on the wheels and connections and inclination of trains as function of the stiffness of the derailment provisions and the train velocity when hitting these.

<table>
<thead>
<tr>
<th>Stiffness</th>
<th>Velocity [km/h]</th>
<th>Force on wheel [kN]</th>
<th>Force on connection [kN]</th>
<th>Inclination [rad]</th>
</tr>
</thead>
<tbody>
<tr>
<td>$9 \cdot 10^9$ (concrete)</td>
<td>1.5</td>
<td>175</td>
<td>210</td>
<td>$-\cdot 5$</td>
</tr>
<tr>
<td>$9 \cdot 10^8$</td>
<td>2.0</td>
<td>465</td>
<td>440</td>
<td>$-\cdot 5$</td>
</tr>
<tr>
<td>$9 \cdot 10^7$</td>
<td>2.0</td>
<td>425</td>
<td>390</td>
<td>0.034</td>
</tr>
<tr>
<td>$9 \cdot 10^6$</td>
<td>3.0</td>
<td>580</td>
<td>564</td>
<td>0.052</td>
</tr>
<tr>
<td>$9 \cdot 10^5$ (steel)</td>
<td>2.0</td>
<td>231</td>
<td>210</td>
<td>0.035</td>
</tr>
<tr>
<td>$9 \cdot 10^4$ (steel)</td>
<td>3.0</td>
<td>349</td>
<td>321</td>
<td>0.053</td>
</tr>
</tbody>
</table>

It appears that for certain combinations of distance to the track (and thus of the velocity with which a derailed train hits the derailment provisions) and stiffness, the forces become so high, that the connection between the bogey and the carriage breaks (over 500 kN). Another important conclusion is that the selection of the stiffness of the derailment provisions seriously influences the forces on the train. The stiffness of concrete is estimated at $9 \cdot 10^9$ N/m, of steel at $9 \cdot 10^6$ N/m, the selection of steel therefore leads to significantly lower forces (but is only necessary when the distance to the track is higher).

We will not discuss the issue of where to place the derailment provisions in this paper, on the outside or the inside of the track. Both appeared to be possible, and the project organisation chose provisions on the inside, because these have a lot of practical advantages.

CONCLUSION
Using the Integral Safety Plan showed to be both possible and constructive. The results of the analyses of the incident type derailment show that derailment provisions are necessary and possible. This lead the project organisation to the adopt of the measure. Also, the analyses gave useful insights into the construction of the derailment provisions.

BIBLIOGRAPHY


5 Not calculated.
6 Train disintegrates, forces are too high.
Today the transport emergencies prevention becomes the necessary part of the functioning of any local risk management system. Really a lot of such emergencies cause not only the death or injury of many people but also (for example, in the case of hazardous cargo to be transported) the large-scale environmental consequences. Meanwhile the driver's behaviour remains to be the main source of the risk above mentioned. The paper describes the methodology developed for creation of transport risk prognosis by means of special expert procedure utilization. An important feature of this procedure is the desire to construct the model of driver's behaviour in extremal situation. The model takes into account: (i) the driver's age; (ii) the experience to be accumulated; (iii) the level of recent trainings; (iv) the individual psychological characteristics; (v) the state of the driver's health. The extremal situation in turn is considered as the situation of conflict between the conditions of movement (which in particular include the speed of transport aids, the current weather parameters, etc.) and the safety requirements. So the aim of expert procedure is to give an estimation of inadmissible consequences possibility as well as to formulate the informative recommendations regarding the driver's training. The efficiency of the approach to be proposed is illustrated by the conclusions from the treatment of expert estimations in relation to St.-Petersburg transport emergencies sample data.
TRACK 1

SESSION 3

TECHNOLOGICAL RISK-CULTURE & BEHAVIOUR
Today, the transport emergency processing becomes the necessary part of the functioning of any local risk management centre. As a result of such emergency there is only the death or injury of many people, but also a serious economic loss of human cargo to be transported. The IAEA's risk management recommendations for each source of the risk above mentioned. The paper describes the methodology developed for analysis of transport data prioritizing by means of expert and agent priority utilities. An important feature of this methodology is the design to optimize the model of driver's behavior in emergency situations. The model takes into account the driver's training level, the weather conditions during the journey, and the risk perception by the driver. The risk perception is determined by the individual professional experience of the driver.
SAFETY CULTURE, SHARED VALUES AND PRACTICES

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INTRODUCTION
The beginning of the 90's was marked by the realisation of the importance of organisation in industrial safety. The analyses of some major accidents have shown how organisational root causes can partly explain these disasters (Starbuck and Milliken, 1988 ; Reason, 1993 ; Vaughan, 1990 ; Paté-Cornell, 1993). At the same time, several researchers provide a conceptual frame to understand the organisational influences on the safety of industrial systems (Turner, 1976 ; Perrow, 1984 ; Reason, 1995 ; Hollnagel, 1995).

Despite numerous attempts to integrate organisational aspects into risk analysis (Embrey, 1986, 1992 ; Paté-Cornell, 1993 ; Paté-Cornell and Fishbeck, 1993 ; Paté-Cornell and Murphy, 1996 ; Davoudian, Wu and Apostolakis; 1994), it is still very difficult to achieve. We have argued (Abramovici and Bourrier, 1999) that these methods were «management tools» (Paté-Comell and Fishbeck, 1993 ; Moisdon, 1997) limited to improving organisational structure and safety but which fall short of offering a clear understanding of relationships between organisation and safety. We introduced the concept of «influence mechanism» (Abramovici, 1999) to define the ways in which organisation influences safety (for example «this division of labour should improve safety because it allows ... »). Thus we decided to focus on these «influence mechanism» to render explicit how organisational devices can contribute to safety.

OBJECTIVES AND METHOD OF THE STUDY
This paper presents the main results of applied research conducted in the French railway industry. The aim of this study was to render explicit the «influence mechanism» justifying from the stand point of the managers, the decision to change the organisation of the Invalides train control section to improve safety. The study took place some months after this decision and was conducted before the organisational change became effective.
First we observed the functioning of the train control section and conducted interviews with the safety managers in order to clarify the current organisation structure and the limits to safety. Then we asked the managers to describe the new organisation and its consequences on system function and safety. These analyses were based on ten meetings of a work group bringing together the safety managers and the executive manager of the train control section. We used event trees to formalise links between organisation and risk (viewed as expected scenarios, likelihood and consequences of these scenarios, see Kaplan, 1997). Surprisingly, before this last task, the analysis of the organisational change by the group was not linked to «risk» but to organisational objectives which can be described as follows:

• contributing to the respect of the rules,
• making the individual mastery of work easier,
• clarifying responsibilities,
THE NOTION OF SAFETY IN THE TRAIN CONTROL SECTION

This result led us to study the concept of safety in this installation. This was done by using a questionnaire administrated in spring 1998 among almost all the operators of the Invalides train control section including the three managers of the work group (26 respondents).

The questionnaire contained two parts. The first allowed us to describe and analyse social representations using systematic measurements of social and organisational value systems (Pournadère and Mays, 1988; Mays and Pournadère, 1989). We chose four themes: current attitudes in the train control section, safety in daily work, rules and procedures, desired attitudes.

The second part contained twelve definitions of safety with five-point scales for evaluating respondents’ agreement with them. Each questionnaire was completed in our presence and we noted all the comments made by the respondents. These spontaneous reactions help us to analyse the social representations related to safety.

Our results showed three aspects strongly related to safety for the operators of this system: respect of the rules, individual mastery of work and collective mastery of work. These results were mostly coherent with the hypothesis used by the managers to justify their organisational choices. We found that this manifest agreement on the question of safety was based upon a common understanding of the organisational objectives necessary to guarantee safety. This result explained our difficulties to link organisational change to the « risked » scenario in the first part of this study.

AN APPROPRIATE METHODOLOGY TO EXPLORE SAFETY CULTURE?

The consensus around what were perceived as appropriate ways to improve safety lead us to address the concept of safety culture (Schein, 1990; Pidgeon, 1998). Our methodology allowed us to make explicit « influence mechanisms ». We found that these hypotheses were linked to the organisational objectives perceived as adequate to improve safety in train control section. Thus we were able to explore some part of the « pattern of basic assumptions invented, discovered or developed by a given group » (Shein, 1990) to cope with their problem to manage safety.

Moreover, we found that these hypotheses were coherent with the value system associated with safety as measured by the questionnaire. We believe that systematic measurements of social representations could be an adequate way to better understand the culture of a specific system. This is mainly because such measurement does not require the predetermination of what a safety culture should be. The only criterion that we used to judge the « quality » of safety culture was the degree of members’ consensus. Then, this methodology allows us to find results quite different from what we believe true a priori. For example, we were quite surprised to see that value questionnaire items on « protecting less able members, providing help when needed » and « equality, democratic participation in decision making » were much chosen and strongly related to safety for the Invalides train control section members.

CONCLUSION

To conclude, this study showed how to render explicit « influence mechanism » in order to better understand how organisation contributes to the safety of industrial systems for the members of this system. The methodology used gave great importance to the beliefs of the members of the organisation in accordance with the principles of decentralising risk analysis (Mays and Pournadère, 1989). Thus, bringing together our methodology and the concepts introduced in the analysis of safety culture seems both adequate and promising.
REFERENCES
Much of the recent discussion of technological stigma and its consequences for public perceptions of risk has framed stigma in terms of negative economic impacts. To a great extent the economic framing reflects policy priorities and concerns. This framing can be seen as characteristic of a widespread tendency within the public policy domain to apply economic criteria when addressing environmental and risk issues. However, framing the issue in economic terms also obscures the nature of technological stigma and its social consequences. The consequences for a community of having a hazardous installation sited in the vicinity are not simply economic. Our paper demonstrates the limitations of the economic model which informs much of this recent writing on the subject and proposes an alternative, richer account which better captures the human and social consequences of technological stigma.

In the paper we return to Goffman’s classic study of stigma as our starting point. Taking our cue from Goffman’s conceptualisation of stigma in terms of spoiled identities, we examine the ways in which the presence of hazardous industrial installations can affect the identity of a place and the everyday social impact that this can have on the local community. By drawing on recent empirical research around hazardous sites in Britain and setting these processes in specific contexts, we outline a socio-cultural account of technological stigma. Among other things, this perspective draws our attention to the consequences for local senses of place, as well as highlighting the ways in which technological stigma interacts with other forms of local stigma.
THE ROLE OF HUMAN PERFORMANCE IN THE SAFETY COMPLEX PLANTS’ OPERATION

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ABSTRACT
According to statistics, about 20-30% from the failures occurred in the plants are caused directly or indirectly by human errors. Furthermore, it was established that 10-15 percents of the global failures are related with the human errors. These are mainly due to the wrong actions, maintenance errors, and misinterpretation of instruments. The human performance is influenced by: professional ability, complexity and danger of the plant, experience in the same work place, level of skills, events in personal and/or professional life, discipline, social ambience, somatic health. The human performances’ assessment in the probabilistic safety assessment offers the possibility of evaluation for human contribution to the events sequences outcome. Not all the human errors have impact on system. A human error may be recovered before the unwanted consequences had been occurred on system. This paper presents the possibilities to use the probabilistic methods (event tree, fault tree) to identify the solutions for human reliability improvement in order to minimise the risk in industrial plants’ operation. Also, are defined the human error types and their causes and it is presented the “decision tree method” as technique in our analyses for human reliability assessment. The exemplification of human error analysis method was achieved based on operation data for Valcea heavy water pilot plant. As initiating event for the accident state has been considered the “steam supply interruption” event. The human errors’ contribution was analysed for the accident sequence with the worst consequences.

The increase of safety in industrial plants operation represented and represents a preoccupation of the specialists in the domain of reliability. Unfortunately the attention was directed only to the equipment’s reliability, the human factor being neglected for a while. According to statistics, about 20-30% from the failures occurred in the plants are caused directly or indirectly by human error. Furthermore, it was established that 10 - 15% from the global failures are related with the human errors. These are mainly due to the wrong actions, maintenance errors, and misinterpretation of instruments. The addressing of human performances in the probabilistic safety assessment offer the possibility of evaluation of human error contribution to the occurrence of the event/accidents sequences.

The importance of human error depends on its social and economic consequences. The human error is any member of set of human actions that exceeds a limit of acceptability. It is an out-of-tolerance action, where the limits of acceptable performances are defined by the system.

Not all of human errors result in system degradation. An error can be recovered or corrected before it results in undesirable consequences to the system. This recovery factor may be the result of human redundancy, for example, someone checking another’s work, or the system itself may detect an error before any consequences occur. Reliability is the antithesis of error likelihood and is the probability that no error occur. Reliability is conventionally defined as the probability of successful performance of a mission.
The human reliability was defined as the probability that a job or task will successfully be completed by personnel at any required stage in system operation within a required minimum of time (if the time requirement exists). /1,2/

The human error probability is the probability that when a given task is performed, an error will occur. It is calculated as the ratio of errors committed to the number of opportunities for that error, or an estimate of that ratio.

Performance - Shaping Factors (PSF'S)
The performance - shaping factors can be categorised in two groups: external and internal. External PSF's are those outside the individual, brought to bear by the environment or task. Situational task and equipment characteristic’s (PSF’s) that predispose workers to increased errors include the following: inadequate work space and work layout, poor environmental conditions, inadequate human engineering design, inadequate training and job aids procedures, poor supervision.

Internal PSF are those that operate within the individual. They are human attributes such as skills, abilities and attitudes that the worker brings to the job. If training has been adequate, however, internal PSF’s generally have less impact than external PSF’s on human reliability. This is fortunate because the external PSF's are nearly all under the control of industrial management and, if identified as contributing to errors, can be modified. Some examples of internal PSF’s are: training/experience, skill level, intelligence, motivation/attitude, emotional state, task knowledge, social factors, physical condition, stress level.

The pre - accident and post - accident human errors (except human error of decision) can be quantified using decision tree method. The method consists in developing a structured tree that contains questions related to factors implied in human error quantification. The method requires the quantification of each factor with an exponent value. The factors are: /3/

EA - immediate emergency action for critical parameters
   EA1 - YES
   EA2 - NO

PR - written procedures are available for the action
   PR1 - YES
   PR2 - NO

AC - actions complexity
   AC1 - step - by - step task
   AC2 - dynamic task

SL - stress level (concerning available time and general plants date)
   SL1 - low stress
   SL2 - moderately high stress
   SL3 - extremely high stress

SC - second check (between person dependence)
   SC1 - there is someone who has to verify the correctness of the critical action
   SC2 - nobody else verifies the correctness of the critical action.

Example - application for heavy water pilot plant Rm. Valcea
In this paper will be presented methods for human error analyses based on operation data of heavy water pilot plant from Rm. Valcea. As initiating event of the accident state will be considered the “process steam interruption” event. The human error contribution will be analysed for the accident sequence with the worst consequences.
The 13 ate steam, is used in the primary isotopic concentration by chemical water-hydrogen sulphide plant as thermal agent and as stripping the agent from the product and waste of dual temperature plant. The cutting off the steam conducts to no-operating in the stage I dual temperature of the S305 heater and in the installation of waste stripping to no-operating of stripping column CL401 and of the S401 heater.

To avoid the dangerous situation, at the 13 ate steam in the previously specified conditions the next actions must be made:
- steam pipe isolating
- separation of isotopic exchange between stages
- adsorption shut - down
- stripping shut - down
- cycling of liquid to isotopic exchange
- cycling of liquid from stripping to absorption.

The possible causes of no performing the emergency interventions post-accident are analysed by the mean of fault trees. The emergency interventions consist in regulations valves closing, section valves closing, closing and/or opening mechanical valves, starting - and/or shut down centrifugal pumps. The causes of noclosing of regulating and section valves can be mechanical electrical or human: push button mechanical failure, output regulator blocking, driving circuit failure, human error, etc. The noclosing/noopening causes can be mechanical or human.

The fault trees are qualitatively evaluated by Boolean minimising until is obtained the minimal cut set /4/. After the fault tree approach it were calculated the importance factors RAW (Risk Achievement Worth), RRW (Risk Reduction Worth) in order to observe the each human error contribution to system fault. The calculus formulas were:

\[
RAW = \frac{R_1}{R_o}
\]

Where: \( R_1 \) - the risk level if the error certainly occur (probability 1)
\( R_o \) - nominal risk level

\[
RRW = \frac{R_0}{R_1}
\]

Where: \( R_o \) - nominal risk level
\( R_1 \) - the risk level if the function is optimised (probability 0)

By the integrating of the six fault trees in the event tree it were determined the appearance frequencies of the 20 accident sequences, considering for the initiating event an appearance frequency of \( 250/1000 \) yr.

The most unfavourable situation by consequences’ gravity point of view is the fail of all safety systems, conducting to unstripped water evacuation to the treating water basin and entering \( H_2S \) steam feed pipe-line of column CL401. Due to this reason the analysis of the human errors contributions to the accident sequence will be made for this accident state.

The unavailability value of the accident sequence steam pipe nonisolating, nonseparation of isotopic exchange between stages, adsorption nonshut – down, is \( 2.14053 \cdot 10^{-10} \).

The fact that there are many possibilities for components’ isolation in emergency situations explains the reduced frequency of the analysed accident sequence. There were made importance analyses for the analysed accident sequence. It were calculated the RAW and
RRW values. The results obtained are presented in tables 1, 2 being selected only the significant values. Also, is shown the importance of the others basic events in ascending order of the contribution, to see more clearly the rank of human error in risk level.

By RAW values point of view, the human error VR421 fail to close (/VR421/HE/) is the most significant, the certain occurring of this error conducting to risk level increase of $10^2$. This fact is explainable having in view the fact that VR421 is the only element of cutting off with automatic control, VR309 is covered by a section valve what conduets to the reduction of the influence on the risk level. The RRW values show a reducing of risk level with $10^2$ in the human error absence.

The results of analyses of human errors importanee denote de check necessity and rigorous periodic training of operating personnel, and if it’s possible the automatization of emergency intervention.

<table>
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<th>Basic event</th>
<th>New value</th>
<th>RAW</th>
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Table 1 RAW values in descending order

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Table 2 RRW values in descending order

REFERENCES
The development of Intelligent Decision-Support Systems (IDSS) for Emergency Management is a new interdisciplinary research activity. Its objectives are to increase the efficacy of emergency management and to reduce the probability of human decisional errors. Emergency manager decision making depends on available information on emergency situation, resources, his/her manager role, mental capabilities and characterological profile. He/she must take under consideration possible domain-related static and dynamic risks, as well as he need to evaluate risks related to the execution of different intervention alternatives. An intelligent computer support should relay on the suggestion of actions/interventions and on an explanation of their motivations.

In order to design IDSS, the above requirements have to be presented in frame of a generic emergency scenarios and formal decisional models. The paper presents a general decision-making model in the context of emergency situations and analyses how different risks and their properties are employed in the decision-making reasoning processes, it is a new point of view on Risk Based Reasoning problems. The accepted IDSS architecture is based on multiagent cognitive system. The modeling in presented according to the TOGA (Top-down Object-based Goal-oriented Approach) conceptualization framework.

REFERENCES


TRACK 1

SESSION 4

TECHNOLOGICAL RISK – APPLICATIONS
TRACK 1

Session 4

TECHNOLOGICAL RISK APPLICATIONS
RISK ANALYSIS OF FIRE PROTECTION SYSTEM USING BAYESIAN NETWORKS

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ABSTRACT
Bayesian belief network is used to analyze a fire protective system. Typical nodes of the network include fire start, detection, tampering, sprinklers, smoke detection, fire brigade, fire flashover, and structural failure. Performance of a fire protective system is characterized by appropriate causal links and input conditional probabilities. The decision nodes and utility nodes are implemented to enable fire risk assessment. It appears that Bayesian belief networks provide an effective tool to analyze fire protective systems.

INTRODUCTION
Safety in case of fire is one of the essential requirements imposed on construction works by Council Directive 89/106/EEC. Experience and available data indicate that depending on particular conditions and applied fire protection system, the probability of fire flashover (outbreak) may be expected within a broad range. It appears that Bayesian belief networks provide an effective tool to find a more accurate estimate for the probability of fire flashover and to propose an optimum fire safety system in rational way /1/, /2/.

Under several conceivable networks including networks with active measures (sprinklers and fire brigade) one typical network is considered in presented study. The network consists of fire start, detection, tampering, sprinklers, smoke detection, fire brigade, fire flashover and structural failure. All nodes are inter-connected by directional links corresponding to causal dependencies of relevant nodes.

BAYESIAN NETWORK
A typical Bayesian belief network representing a fire safety system of an office building is indicated in Figure 1. The network consists of ten chance nodes, labelled by numbers 1 to 10 (and two auxiliary chance nodes 3', 4'), one decision node 11, and four utility nodes 12, 13, 14 and 15. Bayesian network supplemented by decision and utility nodes is often referred as influence diagram. The decision and utility nodes are implemented to enable risk assessment in terms of relevant costs. The network can also be used to make decision on optimum fire safety system by minimising the total cost due to installation of sprinkler system (node 12), sprinklers and fire brigade operation (node 13), fire flashover (node 14) and structural failure (node 15). Description of all nodes (chance, decision, and utility nodes) is summarised in the following sections.

At present all the nodes are described by alternative random variables (having two states only). The input data consist of conditional probabilities of node states related to appropriate states of parent nodes (if there are any). These conditional probabilities can be assessed using a combination of theoretical insights /3, 4/, empirical studies, and various more or less subjective estimates. However, main advantage of the network is the clear definition of all input data, which may be therefore adjusted on the basis of new information, and a very good insight into the network analysis /5/.
Figure 1. Bayesian network used for fire risk analysis and assessment.

**Chance nodes**

1. **Fire start**: initiation of a fire (probability of fire starts is dependent on character of fire compartment and assumed design life, for example considering an office area within the period of 50 years the probability of fire starts may be 0.01 /3, 4/); no parent nodes.
2. **Detection by occupancy**: discovery of a smoke by occupancy or neighbourhood within a suitable time period (conditional probability given fire starts may be high); parent node 1.
3. **Smoke detection**: automatic smoke detection system (conditional probability given fire starts and tampering may be very high); parent nodes 1, 3.  
3* - Tampering: interference of random factors with automatic smoke detection system described by node 3 (probability of unfavourable effect may be very low depending on maintenance of the system); no parent nodes.
4. **Sprinklers**: activation of the automatic sprinkler system if installed (conditional probability of activation given fire starts and tampering may be very high); parent nodes 1, 4. 
4* - Tampering: interference of random factors with automatic sprinkler system described by node 4 (probability of unfavourable effect may be very low depending on maintenance of the system); no parent nodes.
5. **Alarm**: acoustic fire alarm system (conditional probability given positive state of nodes 2, 3 and 4 may be very high depending on maintenance of the system); parent nodes 2, 3, 4. 
6 - Occupancy: activity or occupancy of the building to diminish the fire (conditional probability given positive states of nodes 2 and 5 may be low or moderate); parent nodes 2, 5.

7 - Transmission: functioning of manual or automatic alarm transmission to fire brigades (conditional probability given positive state of nodes 2, 3 and 4 may be very high depending on maintenance of the system); parent nodes 2, 3, 4.

8 - Fire brigade: operation of a professional fire brigade (conditional probability given positive state of the node 7 may be high depending on local conditions); parent node 7.

9 - Flashover: development of the fire (conditional probability given positive state of nodes 4, 6 and 8 may be very low depending on maintenance of the system); parent nodes 4, 6, 8.

10 - Collapse: structural failure (conditional probability given fire flash over may be relatively high, for example 0.01/4/; parent node 9.

Decision node
11 - Decision: resolution in design stage concerning installation of the sprinkler system; if the state is "yes", sprinklers (node 4) are installed, if the state is "no", sprinklers are not installed.

Utility nodes

12 - Cost: node describing cost $C_{12}$ of sprinkler system installation, which depends on the state of the node 11 (it is zero if no sprinklers are installed).

13 - Cost: node describing damage cost $C_{13}$ caused by sprinklers (node 4) and fire brigade (node 8) if the fire (node 9) will not flashover.

14 - Cost: node describing damage cost $C_{14}$ assuming that fire flashover (node 9) occurred

15 - Cost: node describing damage cost $C_{15}$ related to the states of the node 10.

Total cost

The total expected cost $C_{\text{tot}}$ may be written as a sum

$$C_{\text{tot}} = C_{12} + C_{13} + p_{F} C_{14} + p_{F} C_{15}$$

(1)

In this equation $C_{12}$ is the installation cost depending on the state of node 11, $C_{13}$ is the damage costs depending on the states of nodes 4, 8 and 9 (as described above). Further $p_{F} C_{14}$ is expected cost due to fire flashover, where $p_{F}$ is probability of fire flashover and $C_{14}$ is the damage costs given the fire flashover (node 9 is in the state "yes"). Finally, $p_{F} C_{15}$ is expected cost due to structural failure (collapse), where $p_{F}$ is the resulting probability of structural failure (which must be determined using the network) and $C_{15}$ is the damage costs given the structure fails (node 10 is in the state "yes").

EFFECT OF SPRINKLERS

The decision node 11 and four utility nodes 12, 13, 14 and 15 supplement the Bayesian network in Figure 1. This influence diagram enables to study efficiency of sprinkler installation considering expected total cost given by equation (1). However, assessment of input costs described by utility nodes (as a rule in relative currency units) is needed.
Figure 2 shows an example (analysed in detail in the previous study /2/) of the total expected cost $C_{\text{tot}}$ versus the cost of structural failure $C_{15}$ assuming the decision node 11 is in positive state of "yes" with sprinklers as well as in the negative state "no" without sprinklers. Both costs $C_{\text{tot}}$ and $C_{15}$ are expressed in a relative currency unit. It follows from Figure 2 that for the cost of structural failure $C_{15} < 10^4$ currency units the total expected cost $C_{\text{tot}}$ is about 2 units and almost independent of $C_{15}$ and decision concerning installation of sprinklers. For the cost of structural failure $C_{15} > 10^4$ currency units the total expected cost $C_{\text{tot}}$ is rapidly increasing, and it is considerably greater for the system without sprinklers than for the system with sprinklers.

![Figure 2. The total expected cost $C_{\text{tot}}$.](image)

**CONCLUSIONS**

Submitted study indicates that Bayesian network may be used to analyse efficiency of fire protective system, and to find most effective arrangements in particular conditions. The network supplemented with decision and utility nodes (influence diagram) can be used for risk analysis and assessment. More information on input data are needed in order to enable further studies on fire risk assessment.

**ACKNOWLEDGEMENT**

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**BIBLIOGRAPHY**


FULL-SCALE EXPERIMENTS ON THE EVALUATION OF BREAKDOWN CONSEQUENCES AT THE GAS-HAZARDOUS OBJECTS AND THEIR PRACTICAL IMPLEMENTATION

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ABSTRACT
Sour natural gas fields are the unique raw material base for setting up such large enterprises as gas chemical complexes. The presence of high toxic H₂S in natural gas results in widening a range of dangerous and harmful factors for biosphere. Emission of such gases into atmosphere during accidents at gas wells and gas pipelines is of especial danger for environment and first of all for people.

Development of mathematical forecast models for assessment of accidents progression and consequences is one of the main elements of works on safety analysis and risk assessment. The critical step in development of such models is their validation using the experimental material.

Full-scale experiments have been conducted by the All-Union Scientific-Research Institute of Natural Gases and Gas Technology (VNIIGAZ) for grounding of sizes of hazard zones in case of the severe accidents with the gas pipelines. The source of emergency gas release was the working gas pipelines with 100 mm dia. And 110 km length. This pipeline was used for transportation of natural gas with significant amount of hydrogen sulfide. During these experiments significant quantities of the gas including H₂S were released into the atmosphere and then concentrations of gas and H₂S were measured in the accident region.

The results of these experiments are used for validation of atmospheric dispersion models including the new Lagrangian trace stochastic model that takes into account a wide range of meteorological factors. This model was developed as a part of computer system for decision-making support in case of accident release of toxic gases into atmosphere at the enterprises of Russian gas industry.

INTRODUCTION
Nowadays there is hardly any need to prove that the problem of technogeneous risks, brought into our life by human mind, inhabits all the mined of mankind. Accidents and their consequences in technosphere have become compared with such natural phenomena as earthquakes and tornadoes. According to statistic, tornadoes occur 700 times per year on the average. About 2% of them cause 120 deaths, the damaged area is about 2.5 sq. km per accident, and material damage is estimated at 70 million $. At the same time there are about 1500 accidents in the world’s oil industry, over 4 % of which result in 100-150 deaths and loss of up to 100 million $.

Similar dynamic although with lesser figures takes place in the world industry. Most of the accidents occur at gas wells and gas and condensate pipelines. Large gas transport systems have been constructed due to the increased rates of gas production. These systems are intended for great gas flows and high pressures. It is necessary to consider them as potentially dangerous objects for environment. 85-90 % of accidents at RAO GAZPROM enterprises
occur at gas wells and gas transmission systems. As a result, the gas industry has lost several billion cubic meters of natural gas. In average the losses are 3.5 million cu. m per accident. The consequences of such emission may be more catastrophic if natural gas contains hydrogen sulfide. In this case gas wells and transmission systems bring new dangerous and harmful factors for personnel, population and environment.

Safety of gas transport systems is very complicated scientific and technical problem required profound investigation and complex approach. Development of mathematical forecasting models for estimation of accident progression and consequences is a basic element of works on safety analysis and risk assessment.

An important stage of development of such models is their validation using the experimental data. The atmospheric dispersion experiments are very expensive and there is a limited number of special experimental works. It is very important that these experiments must be planned and their data can be used for comparison with mathematical models.

FIELD EXPERIMENTAL DESCRIPTION

Such full-scale experiments have been conducted by VNIIGAZ for grounding sizes of hazard zones in case of the severe accidents at gas pipelines that carry natural gas containing H$_2$S. The task of these experiments was to study dispersion of natural gas containing H$_2$S that was released from a pipeline in the near-to-ground layer. The criteria for estimation of risk zones was concentration of H$_2$S in atmospheric air.

Two series of tests were conducted. A producing well with a free output of 3.5 mln cu. m per day and an active 1000 mm dia. And 110 km length sour gas pipeline were used as a source of emergency emission in the first and second series perspective. The second series of test is of practical interest.

For these purposes the special test site has been constructed. It was a desert plane area of 50 km radius not inhabited by people. The equipment allowed to simulate an accident on a pipeline (its break-down and sulfurous gas release into atmosphere) maximally close to the real conditions. Gas was released in horizontal and vertical direction on the 0.5 m height from the ground. The time of release varied in each experiment from a few minutes to a few hours. The volume of released gas varied from 5 to 22 millions of cu. m/day. On the average 1.15 mln cu. m/h of gas and 8.85 tons per hour of H$_2$S were released in each experiment.

During the experiments H$_2$S was the measured toxic component. Its concentrations were measured on the level of 1.5 m from the ground at different distances (1-30 km) from the source of release down wind and by the width of gas cloud. The time between two sequential measures was 30 sec. During the experiment meteorological parameters have been measured and thermal sounding in the 2 km layer have been done.

The pattern of gas mission dispersion was studied on an area of more than 120 sq. km. The experiments were carried out in different seasons and day time during 4 years. Special attention was paid to the experiments conducted under temperature inversion when the intensity of gas emission dispersion was considerably low thus resulted in forming high H$_2$S concentration in the air within large distances from the source.
The H$_2$S concentrations were measured simultaneously at all the distances down wind and by a depth of the gas cloud. The measurements were carried out by a special team consisted of 120 specialists all of them having been provided with protection means against toxic effect of H$_2$S. At each distance there were from 6 to 12 measuring points. A number of measurements at each point was 100-150 while for a test this figure reached several thousands. In order to ensure safety there were observation stations around the test site equipped with transportation means, atmospheric contamination measuring devices, radiocommunication and emergency medical aid. After each experiment visual analysis of fauna reaction to atmospheric contamination was performed.

Three data files for different meteorological conditions were obtained:

1. for temperature inversion and vertical gas release
2. for temperature inversion and horizontal gas release
3. for unstable atmospheric and horizontal gas release.

These data were used for validation of atmospheric dispersion models.

Comparison of the measured concentration fields in cases of horizontal and vertical gas release has shown that the horizontal release is more dangerous for environment. In the first case the measured H$_2$S concentration varied from 4 to 1200 mg/cu. m, in the second - from 3 to 150 mg/ cu. m.

In singular experiments some unexpected physical phenomena were observed. Under calm conditions a gas cloud (in case of vertical release) was divided into 2-3 plumes moving in different directions. The second phenomenon is related to a change in direction of a part of the released gas (in case of horizontal release) when the cloud cross a natural hollows (long ravine).

A lack of valid experimental data for such phenomena enables to make only rough estimates through an indicator of volume fraction of released gas.

In the first case when the gas cloud was divided into three plumes, the latter were interrelated by a volume fraction as 0.25:0.25:0.5, where 0.5 was a gas portion in the plume oriented in a general wind direction and as 0.3:0.7 when the cloud was divided into two plumes. When the cloud crosses the relief hollows, the similar relationships were 0.4:0.6. The first figure related to the fraction of gas release which distributed along the hollow, the second figure relates to the fraction which crossed the hollow.

These phenomena are very important both from theoretical and practical viewpoints for timely defense of people.

When emergency situation requires quick evaluation, the information about a distance $X_j$, Fig. 1a, over which the zone of equiprobable concentration ($q = \text{Const}$) has a minimum width ($b_{\text{max}}$) is of especial importance.
According to the results of the experiments, such empirical dependencies are:

\[ \text{b}_{\text{max}} = 0.062x_{\text{f}} + 60 \text{ for stable atmosphere} \]
\[ \text{b}_{\text{max}} = 0.71x_{\text{f}} + 24 \text{ for unstable atmosphere} \]

In turn, the parameter \( x_{\text{f}} \) is a part of the maximum length \( x \) of the zone of equiprobable concentration and is derived from the experimentally found relationship.

**DISPERSION MODELS VALIDATION**

Nowadays, a lot of different transport models have been developed. These models differ in the considered processes. So-called Gaussian models are still the basic tool for the dispersion calculation and the most commonly used. They are used as the basis for existing standard procedures and safety codes all over the world. The constants included into these standard procedures are derived basing on statistics processing numerous observation and experiments on impurity distribution.

Most of these experiments are conducted in rather narrow ranges of conditions: ground-based sources. A wind speed of 5-10 m/sec, certain type of terrain and horizontal scale up to 10 km. The use of this experimental data is allowed only under the conditions for which this data were obtained. One must be very careful to apply this data for other conditions of impurity transport.

Agreed-upon area where Gaussian models can be used is 10-20 km. For greater distances, inhomogeneity of meteorological fields influences the dispersion, and it is recommended to use more complicated methods (for example, Lagrangian trajectory methods). Lagrangian track models take into account the real inhomogeneous and non-stationary meteorological fields, complex terrain, precipitation, etc. Lagrangian model takes into account the structure and general similarity laws for atmospheric boundary layer. This fact allows to suppose that such models can be applied in a wider range of weather conditions that differ from the conditions of the basic experiments (wind speed differs from 6-10 m/sec, elevated sources). Under these conditions, standard methods and Lagrangian model can give different results even in the area of applicability of Gaussian methods. However, as it is known, more complicated models do not guarantee better results. In this case, it is very important to compare the results of these methods with experimental data.
The material described here gives a good opportunity for validation studying. The experimental data is compared with the results obtained by using several different models.

The first model is a famous Pasquill model.

The second one is the Gaussian model recommended as standard in Russia for assessment of concentration of radioactive materials in air in case of emergency situation on Nuclear Power Plants /1/.

The third one is a Gaussian model widely used in USA and Europe as a standard. It is based on approximation formulas for horizontal and vertical impurity dispersion /2/. This model is a basic one /3/ in recommendations of the Environmental Protection Agency for assessment of consequences of radioactive and other industrial releases and is included in many European recommendations.

The fourth one is the Lagrangian stochastic trace model included in integrated package ‘NOSTRADAMUS’ /4/. It was developed at Nuclear Safety Institute of Russian Academy of Science and is intended for decision-making support in emergency situations at NPPs and other dangerous objects. It is intended for calculation of impurity transport in the atmosphere depending on meteorological situation, type of terrain and other factors, including horizontal, vertical and time inhomogeneity of wind field.

Figures 1-2 show the results of comparison of calculated and experimental data. They show normalized concentration of H2S, n*, near the plume axis as a function of the distance from the source for different classes of atmosphere stability. (n* = NV/Q, where N is a concentration of H2S in g/cm³, V is a wind velocity in m/sec, Q is source intensity in g/sec). Fig. 1 corresponds to unstable atmosphere, Fig. 2 to stable atmosphere.

Fig. 1. Comparison between measured and calculation H2S near-ground density at the trace axes. n* = NV/Q, where N is a concentration of hydrogen sulfide in g/m³, V is a wind velocity in m/sec, Q is source intensity in g/sec. Unstable atmosphere (Turner A class).
Spots - experimental data;
1 - Pasquill model;
2 - Russian standard model;
3 - EPA standard model;
4 - Lagrangian trace model.

Experimental data is shown by spots. This data was obtained in different experiments and at different times from the release beginning. In all experiments gas release was horizontal, therefore there was no elevation of the jet. The propagation of released gas was occurring over the plane area. Wind speed in these experiments varied in the range of 1-5 m/s. The theoretical curves obtained by using the above-mentioned models are also shown here.

Fig. 2. Comparison between measured and calculation H₂S near-ground density at the trace axes. Stable conditions (Turner F class). Other notations are the same as on Fig. 1.

In case of relatively simple conditions of an experiment (as for these spots) all the models give close results and it is difficult to choose the best one.

As mentioned above /5/, the comparison of experimental data with predicted ones has revealed a good deal of discrepancy both for unstable and stable atmosphere. Under unstable conditions measured and predicted concentrations are close at short distances (<1 km). At long distances the models underestimate concentrations by a factor of 3-10. Under stable conditions Pasquill model overestimate concentrations by factor 4-6 compared to experimental study.

At the same time it may be seen from the figures that for stable atmosphere Lagrangian models give smaller concentrations than both standard Gaussian models. It is due to the change of wind direction with height. This fact is better displayed in the case of stable atmosphere. For these conditions Lagrangian model better corresponds to the experimental data. Under stable conditions the all models overestimated impurity concentrations in plume.
The existing experimental data are a good basis for validation of such models. At present VNIIGAZ and the institutes of Russian Academy of Sciences are conducting the works on testing Lagrangian model in calm conditions and in conditions of dispersion over complex terrain.

CONCLUSIONS
Emergency release of harmful substances into atmosphere can lead to situations dangerous for people and environment. The size of hazard zone in this case can be of tens kilometers. Therefore, the described scenario of accidents’ consequences cannot be ignored in a real situation. This is the base for working out emergency plan and protective measures to safeguard public health. It is very difficult problem because there are no methods for modeling all described accidents’ scenario. VNIIGAZ and leading institutes of Russian Academy of Sciences conducted theoretical investigations of such phenomena basing on experimental data. Validation of mathematical atmospheric transport models using experimental data is very important part of this work.

The results of the above experiments were used as the base for strategic decisions for providing safety measures for population including the relocation of several villages out of the region of the deposits of sulfurous natural gases.

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FIVE YEARS OF SOSNOVY BOR RISK - PROJECT

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At the conference in Vienna (Austria) on preparation of document for risk assessment and management in 1994 Sosnovy Bor city associated with high risk of residing in small territory, where many enterprises nuclear industrial and chemically of dangerous complex are located.

To this moment concept " the analysis of risk " has received a wide dissemination already. The Sosnovy Bor city was included by first and unique in Russia in the framework of the Program IAEA/UNIDO/UNEP/WHO on the basis of methodological materials prepared by the world community on risk assessment and management in large industrial complex. The decision on the appeal to the Program was accepted by local authorities in agreement with Ministry of atomic energy of Russia and assistance of the experts of Agency on protection of Environment DCMR (Netherlands) and IAEA. The positive factor for carrying out of Sosnovy Bor case study was that the Guide was almost ready.

Five years have passed.
As the further practice has shown, not all propositions of this document has become acceptable for Russia, in particular for Sosnovy Bor city.

The population of city is 63 000. The city is located on a southern coast of a Finnish gulf of the Baltic sea in 80 kilometers from world wide known St.-Petersburg.

What attracted the attention of the IAEA experts?
The major industrial enterprises of Sosnovy Bor city are:
Leningrad Nuclear Power Plant;
Construction Materials Plant;
Rad Waste Storage and Treatment Plant “RADON”.
We have also a number of research institutes:
The Research Institute for Nuclear Technologies;
Research Institute of Optics and Optoelectronic Devices;
Research and Design Institute;
Branch of the “Institute of Radium” Scientific Center.

During the first year of the Sosnovy Bor case study we did work on danger sources inventory and set research priorities.
We should note that we consider both radiological and chemical risks.
The radiological risks are:
4 RBMK reactors of Leningrad Nuclear Power Plant;
facilities of Rad Waste Storage and Treatment Plant “RADON”;
reactors of Research Institute for Nuclear Technologies.
As for chemical risks, we have:
A chlorine storage at the sewage treatment unit of enterprise “Vodokanal”;

A chlorine storage at the drinking water treatment plant; Fuel storage and stations; Refrigerating equipment of fish cannery and food storage.

Hazardous materials are transported to and from Sosnovy Bor city by rail, automobile roads, there are also gas distribution line. Many potentially dangerous installations are going to be developed in our area in the nearest future. The more important ones are: Reconstruction of Leningrad Nuclear Power Plant and replacement of old reactors; it is expected that 4 new channel-type reactor units MKER-1000 will be constructed before old unit decommissioning; the first power units was put into operation in 1973 and in compliance with current requirements it is to be decommissioned in 2003; The Research Institute for Nuclear Technologies plans to create the Federal North-West Science and Engineering Center of Nuclear Energy on its site; an experimental power unit of WWER-640 will be build here under the project; In accordance with regional and federal plans for nuclear industry development a new rad waste storage facilities will be build in Sosnovy Bor area because the existing one has limited capacities; An oil terminal is going to be constructed 9 km from Sosnovy Bor city.

Attempts of local authorities to determine the further destiny of city were undertaken in 1989. Due to desire of a public the local authorities have addressed to a chief expert body of the country - ministry of USSR on Environment, to Main ecologist of the country. However, the disintegration of Union has not enabled to finish work on an ecological situation in Sosnovy Bor city.

A lot of information about natural resources, pollution of air, water, ground, wood was gathered. There was no only information on a condition of ecological safety of the enterprises both risk for the population and environment from emergencies and disasters. One more feature of city is that being the city with high concentration of industries Sosnovy Bor attract attention of ministries and agencies of different levels as a place for their pilot research programmes. Other factors explaining this special place of the city in new developments are the interest of local administration in case study, high professional level of local experts and the urgency in elaborating principals of sustainable development for Russian cities of Sosnovy Bor type. If to speak about organization of Sosnovy Bor case study, we have met with the first contradiction to the Guider of IAEA: the creation of groups on democratic principles does not allow to study technological aspects and commercial projects of the city enterprises. So, in territory of city there is no one organization having the complete information on the present and future industrial development of city. A part of the information have the supervising bodies and their rights have not to transfer to somebody. A part of the information have the local authorities and projects of private enterprises - only businessmen. In addition, the supervising bodies examine projects frequently without the account of complex influence.

Therefore local authorities have chosen other principle of organization of works. The department of Natural Resources and Environmental Safety Management was created in administration of the city. The Head of a department is the coordinator of works on Sosnoby Bor case study and collects results separate subprojects. The works are carried out by various organizations on a contractual basis. The financing is carried out by the administration of city, Ministry of an atomic energy ministry of a science and technical policy of Russia. The
databases and computer programs are installed in administration of city. Here the information systems develop to allow to carry out some accounts and to fill up databases.

By the way, we have done the assessment of the existing chemical risks using the methodology supplied by Dutch experts. As a result we came to a conclusion that the level of existing chemical risks is insignificant. Today we have the computer program for account of risks and the GISystem with risk zones in administration of the city. About it is told in post presentation on this conferences.

So, that we have now?

After consideration the following priorities were selected as most urgent:
- Probabilistic Safety Analysis of existing nuclear unit of RBMK type and rad waste storage facilities (unfortunately we do not have practical tools for such risk assessment yet);
- Probabilistic Safety Analysis of nuclear industry facilities MKER type;
- Safety Analysis of planned chemical hazard of the terminal in Batareynaya Bay;
- Safety Analysis of joint operation of all enterprises;

Development of laws and regulations for the local administration and recommendations for the federal and regional level government based on risk analysis.

In 1999 the considered problems are as follows: the management of household waste, seismic monitoring system, influence of financial difficulties on a level of radiological safety, establishment of the regional children's centre of resources saving, the civil defense center in the city administration. The preparation of research for the next year is conducted.

As the result of the Risk-project the opinion about the most serrious dangers in the city have changed, the directions of activities in the sphere of natural resources use and environmental safety are determined, the environmental protection plans at the industries are made, the accident warning system is improved.

But it is unsufficiently to have the information only, it is necessary to use this information. For this purpose it is necessary to have practical tools for management of a situation.

So, we have two ways:

- Using the Russian laws to bring in the contribution to various actions of federal structures;
- If the legislation allows, to make decisions independently at a local level.

Unfortunately, to establish a limiting level of acceptable risk we can not someself.

Lately in Russia many new laws are issued. For example, the law on licensing (1998) and the law about declaration of industrial objects safety (1999) are issued.

On the basis of these laws we have created the system of a civil liability insurance of the enterprises - sources of the increased danger. The feature of this system is that the part of financial means is transferred in local authorities special fund for acceptance of measures on risk reduction.

Using the right to receive the information concerning safety of territories and health of the population we consider the new projects and require to analyse risk. The declaration on intentions is agreed if the risk is insignificant. In this case we check that the estimation should be complex and the risk in territory keeps acceptable. There are facts of the negative decisions of local authorities.

Into the competence of local authorities enters only:

1. Creation of a system of the household waste. The choice of technologies is carried out in our city today. The influence of such technologies on Environment must be least and economic efficiency greatest.
2. Realization of territorial planning in view of a risk accounts. In zones of a possible emergency the residential areas, sports platforms and another are not placed.
3. Strengthening mutual relation with nongovernmental organizations. For last year the administration together with NGO spent 2 international conferences with participation of the representatives of USA, Norway and Finland.
4. Use of principles of resource saving in a city economy.
5. Ecological education and training. This year First stage of creation of the Regional children's Centre of resource saving is completed. Besides the joint research expeditions of the schoolboys from Sosnovy Bor city and Loviisa city (Finland) are organized.

Thus, we are convinced, that the Risk-project is not only accounts, but creation of tools of existing risks reduction, education of the population and future generations, real management of situations today.

For this purpose we plan to decide one more task. Together with federal and regional authorities there is an opportunity to receive the status of city as a city of science for Sosnovy Bor. Such law is issued in our country in April of this year. The law allows to have privileges for development of scientific potential of city. The state interest is a safe development of atomic engineering. About it, I hope, you could hear at the following conference. The preconditions for this work are now.

We are sure that our Risk-project has passed on the following level. For its successful progress the development of the legislation is necessary. The main task is to develop tools of achievement of an acceptable risk level in territory.

In our opinion, it is necessary:
1. To develop a number of the documents on risk management for politicians and the decision making persons, including on international level.
2. To determine the right of local authorities legislatively to establish a level of acceptable risk in the territory in view of local natural conditions, social standards and of available dangers already.
3. To determine conditions of transition to sustainable development in areas with concentration of potential dangers and in a context of influence without borders.

The results of Risk-project has given very much to our city. I hope, that the future of city will be stable and prospering due to the project.
ANALYSIS OF RISKS FROM NATURAL AND MAN-MADE HAZARDS FOR THE URAL INDUSTRIAL REGION

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ABSTRACT
The Urals is one of the most industrialized and urbanized regions of Russia with high concentration of hazardous industries (including nuclear one) that handle, produce, process, and store vast amount of hazardous materials. In spite of sharp decrease of industrial production output in the last decade, losses from natural, industrial and social accidents remain high. So the priority assessment for protection of population, economy and environment from natural and technological hazards is the objective of vital importance. As the first step to the risk management natural and technological hazards in Sverdlovsk Oblast were identified. Quantitative risk analysis was carried out for natural disaster risk (earthquakes, floods, meteorological hazards, forest fires, infection diseases); technological risk (industrial fires and explosions, ejection of toxic substances, transport and high-pressure pipe-lines accidents); environmental health risk (cancer risk from air and drinking water chemical and radioactive contamination, radon). It was found that not natural hazards and industrial accidents but general welfare and other socioeconomic factors play the key role in mortality rate and economy losses.

The Urals is one of the most industrialized and urbanized regions of Russia with high concentration of hazardous industries (including nuclear one) that handle, produce, process, and store vast amount of hazardous materials. In spite of sharp decrease of industrial production output in the last decade, losses from natural, industrial and social accidents remain high. So the priority assessment for protection of population, economy and environment from natural and technological hazards is the objective of vital importance.

In this paper we have analyzed natural, technological and environmental health risks for Sverdlovsk Oblast. By the level of industrial production output Sverdlovsk Oblast takes the first place among seven Oblasts and Republics of the Ural economic region. Economy of the Oblast is based on reach mineral resources. Sverdlovsk Oblast has 23% in all-Russia iron ore output, 71% in bauxite, 6% in copper ore, 20% in fire-clay and 97% in asbestos output. The industrial specialization of Sverdlovsk Oblast is in the field of heavy industry: ferrous and non-ferrous metallurgy, diversified mechanical engineering, chemical, timber, woodworking, pipe and paper industry. Sverdlovsk Oblast is among the most environmentally unfavorable regions of Russia. Sverdlovsk Oblast is one of the most populated Oblasts of Russian Federation. The main reason of such situation is the extremely high concentration of environmentally dangerous industries. The other reasons are that the most part of the region’s vast mining and metallurgical combines are outmoded, lack of pollution control technologies, pour exploitation of existing equipment for pollution control.

By the number of population it shares the first place in the Ural Economic Region and the fourth place in Russia. On January 1, 1996 its population was 4676.7 thousand people. The area of Sverdlovsk Oblast is 194.8 thousand square km (i.e. 1.1% of the territory of Russian federation). The largest cities are Ekaterinburg (1277.8 thousand people), Nizniy Tagil (408.4 thousand people) and Kamensk-Uralskiy (197.5 thousand people). The most ethnical group is
Russians (88.7%), there are also Tatars (3.9%), Ukrainians (1.7%), Bashkirs (0.9%), Germans (0.7%) and other nationalities.

The main objective of the work was to develop and realize an integrated system approach to risk analysis in industrial region. As the first step to the risk management natural and technological hazards in Sverdlovsk Oblast were identified. Data bases on natural and technological hazards have been created. Individual and population mortality and morbidity risks as well as expected economic losses were assessed. Numerical assessment and comparison of different risks were realized on the bases of statistical approach. Literature data and unpublished data of various specialized organizations on the average annual frequency of accidents and losses were used. Quantitative risk analysis was carried out for natural disaster risk (earthquakes, floods, meteorological hazards, forest fires, infection diseases); technological risk (industrial fires and explosions, ejection of toxic substances, transport and high-pressure pipe-lines accidents); environmental health risk (cancer risk from air and drinking water chemical and radioactive contamination, radon).

According to archive records and seismological observations it were 94 earthquakes in the Urals during last 300 years. Three of these seismic events were of 6.5 magnitude, twenty-six were of 5-6 magnitude and others were less then 5 magnitude. For the territory of Sverdlovsk Oblast it is possible to expect $4.5 \times 10^{-3}$ earthquakes with magnitude 6-7 and $4.1 \times 10^{-2}$ earthquakes with magnitude 5-6 per year.

Average annual number of floods at the territory of Sverdlovsk Oblast is 4.6. For the most risky local territories it varies from 0.2 to 0.8 per year. On the basis of statistics of the Urals Regional Emergency Comity it was calculated that the highest individual mortality risk in the result of floods is $2.9 \times 10^{-6}$ per year. Population risk for the Oblast as a whole is 0.71 deaths per year and expected economic losses are 12.7 billion rubles per year (in 1996 prices).

Average annual number of hazardous meteorological events (snowstorms, strong snowfalls, hurricanes, thunderstorms) at the territory of Sverdlovsk Oblast is 10.6. Individual mortality risk in the result of meteorological hazards is $4.6 \times 10^{-7}$ per year, population risk for the Oblast as a whole is 2.15 deaths per year and expected economic losses are 60.6 billion rubles per year.

Annual probability of tornado passing through populated area is $6.9 \times 10^{-4}$. Corresponding economic risk (expected economic losses) is 0.6 billion rubles per year.

941.7 forest fires ought to be expected annually in Sverdlovsk Oblast. Corresponding economic risk is 5.4 billion rubles per year. The average area passed by one forest fire if 7.4 hectares.

Individual morbidity risk of infectious diseases is 0.2 per year. Particular risks, for example, are 0.03 year$^{-1}$ for influenza, 0.0009 year$^{-1}$ for dysentery, 0.0005 year$^{-1}$ for tuberculosis, 0.00008 year$^{-1}$ for diphtheria and 0.000001 year$^{-1}$ for AIDS.

There are 181 industrial enterprises with the risk of ejection of toxic substances in Sverdlovsk Oblast. The most commonly used toxic substances are chlorine, ammonia and concentrated acids. About 2487 thousand people live in the zone of possible accidental contamination. Estimated average number of accidents with ejection of toxic substances in the environment is 4.1 per year. The highest (in the most dangerous towns) individual mortality risk in the result of ejection of toxic substances is $7.5 \times 10^{-7}$ per year. Population risk for the Oblast as a whole is 0.99 deaths per year.
In Sverdlovsk Oblast there are 78 enterprises that use or store explosives. Estimated average number of accidents in these enterprises is 5.1 per year. The highest (in the most dangerous towns) individual mortality risk in the result of such accidents is $1.9 \times 10^{-6}$ per year. Population risk for the Oblast as a whole is 4.01 deaths per year.

There are 18 gas mains with the tube diameter from 1000 to 1400 millimeters at the territory of Sverdlovsk Oblast. Their total length is about 6100 km. On the basis of statistical data on the frequency and consequences of accidents at pipelines of the Former Soviet Union and Russia it is possible to estimate that the expected frequency of accidents in Sverdlovsk Oblast is 1.8 per year. Predicted individual mortality risk is $6.8 \times 10^{-8}$ per year. Population risk for the Oblast as a whole is 0.04 deaths per year.

Individual risk of death in the result of air accidents is $2.4 \times 10^{-7}$ per year. Corresponding population risk is 1.11 deaths per year.

Railroad transport is more safety: Individual risk of death in the result of railroad accidents is $7.9 \times 10^{-8}$ per year and corresponding population risk is 0.37 deaths per year.

We assessed the cancer risk resulting from air contamination in the largest cities of the Oblast. Average annual concentrations of formaldehyde, benzene, benzyrene, cadmium, nickel, chromium (VI), and arsenic in the urban air were used. Methodology of the environmental health risk assessment of the U.S. Environmental Protection Agency was used. The maximum lifetime individual excess (compared to spontaneous level) cancer risk resulted from chemical contamination of air is $6.1 \times 10^{-4}$. For comparison, currently in Russia the lifetime cancer risk is 0.17 for male and 0.18 for female. So the excess cancer risk due to air contamination is 0.35% of the average spontaneous level. Population risk due to air contamination is 1378 excess cancers in Sverdlovsk Oblast.

The cancer risk resulting from drinking water contamination was assessed for chloroform and carbon tetrachloride. Individual lifetime cancer risk due to contamination of drinking water is $1.6 \times 10^{-4}$. Additional 259.4 cases of cancer caused by drinking water contamination are expected in the population of Sverdlovsk Oblast.

Lung cancer risk in the result of indoor radon exposure was assessed. The average value of excess lifetime lung cancer risk for males is 0.0178 in rural dwellings and 0.0103 in town dwellings. For females the average lifetime excess lung cancer risk is 0.0032 in rural dwellings and 0.0018 in town dwellings.

There is Beloyarskaya Nuclear Power Station in Sverdlovsk Oblast in 35 kilometers to the east of Ekaterinburg. Cancer risk due to radiation exposure in the result of its activity was calculated. In the result of 30-year routine activity of Beloyarskaya Nuclear Power Station 0.027 excess cases of cancer may be expected in the population of Sverdlovsk Oblast. In case of possible accidents 0.12 excess cases of cancer may be expected.

All risk considered above are rank in accordance with their intensity, see Table. For comparison data about some social risks also are presented. It may be concluded that not natural hazards and industrial accidents but general welfare and other socioeconomic factors play the key role in mortality rate and economy losses.
TABLE. Individual natural and technological risks for population of Sverdlovsk Oblast, $10^{-6}$ year$^{-1}$.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>males</th>
<th>females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influenza morbidity</td>
<td>30000</td>
<td></td>
</tr>
<tr>
<td>Suicide</td>
<td>729</td>
<td>189</td>
</tr>
<tr>
<td>Murder</td>
<td>593</td>
<td>174</td>
</tr>
<tr>
<td>Death in the result of alcohol poison</td>
<td>435</td>
<td>106</td>
</tr>
<tr>
<td>Death in the result of other poisons</td>
<td>109</td>
<td>31</td>
</tr>
<tr>
<td>Death in the result of drowning</td>
<td>78</td>
<td>6</td>
</tr>
<tr>
<td>Death in the result of incidents with fire-arms</td>
<td>4</td>
<td>0.0</td>
</tr>
<tr>
<td>Death in the result of spring floods</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Death in the result of industrial explosion</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Death in the result of ejection of toxic substances in industry</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Death in the result of hazardous meteorological events</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>Death in the result of air accidents</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Death in the result of railroad accidents</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Death in the result of pipe-line accidents</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Indoor radon lung cancer (lifetime risk)</td>
<td>17800</td>
<td>3200</td>
</tr>
<tr>
<td>rural dwellings</td>
<td>10300</td>
<td>1800</td>
</tr>
<tr>
<td>Cancer risk from air chemical contamination</td>
<td>6.1 (lifetime risk)</td>
<td></td>
</tr>
<tr>
<td>Cancer risk from drinking water chemical contamination</td>
<td>1.6 (lifetime risk)</td>
<td></td>
</tr>
</tbody>
</table>
CONTROL OF MAJOR HAZARDS IN AUSTRALIA: A TECHNICAL RISK? OR A POLITICAL RISK?

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ABSTRACT
The control of what are generally termed “major hazards” has become an inevitable part of our industrialised world, and is applied particularly to the chemical industry. A recent study (Di Giunta and Prasad, 1998) comparing control processes in U.K, U.S.A. and Australia has lead to three conclusions: our controls are not as adequate as in the two other countries, the reason for the less adequate controls is we have not until recently experienced the disasters suffered by other countries, and there are political factors involved as well as technical.

INTRODUCTION
The presence of “major hazards” in the chemical industry is by now well known and has been covered by Kletz, Roland-Moriarty, Waring, and Pitblado, just to name a few at random, as well as in an increasing range of publications by the American Institute of Chemical Engineers through the Centre for Chemical Process Safety. The nature of “hazards” has also been well documented, and is generally defined as “a condition or situation which has the potential to create or increase harm to people, property, or the environment” (IPENZ, 1983:17).

The reason why the chemical industry presents major hazards is simply that it uses materials which may be flammable, explosive or toxic, or all three together. The industry also used operating conditions involving extreme temperatures and temperatures, and that combination of materials and processes sets up a system which is often inherently hazardous, with the potential to cause an undesired result, as defined by a British standard (BS4779:1979): “A set of conditions in the operation of a product or system for initiating an accident sequence”.

SOME AUSTRALIAN HISTORY
This island at the end of the world has been described as “the lucky country”, and we have had a fortunate history of accidents due major hazards. That is partly due to being at the end of the world, so we are usually technology-followers. Having a small population, which means we have tended to import many products instead of manufacturing locally, is another factor.

Both these factors have lead to a low concentration of hazardous industries. For example: we have eight oil refineries scattered around the country. In Sydney there is a cluster of chemical industry near the refinery at Kurnell, one near the refinery at Camellia, and another at Matraville, with a large storage area nearby at Port Botany, all Sydney suburbs. In Melbourne there is a similar cluster near the refinery complex at Altona, with a large storage area at Coode Island (quite near the city), and another refinery at Geelong. All these facilities are quite close to the cities in question, but none of these are anything like the size of Canvey Island. Then there are many small chemical manufacturers scattered around all the major cities, some handling hazardous materials such as chlorine and benzene compounds.
Our record of major-hazard-accidents makes, by world standards, very dull reading. We had a refinery fire at Geelong some thirty or forty years ago. There was an LPG unconfined vapour cloud explosion in Cairns (North Queensland) in 1987, and there was a chemical explosion in a metals-reclaiming factory in Melbourne in 1986. Coode Island had a tank fire in 1991, and a factory at Seven Hills, an outer Sydney suburb, was severely damaged by fire in 1989.

There were enquiries about those explosions but no definitive, publicly-broadcast, action followed them. The fires were followed by extensive enquiries, but the Seven Hills case has sunk without a trace and although the Coode Island enquiry recommended moving the installation further from the city nothing has happened. The tanks are still there.

THREE EXPLOSIONS THAT ROCKED SYDNEY
In reviewing such major accidents we come to four significant events, four explosions, which have affected the city of Sydney. To begin, we will cover the first three.

The first was in 1986, at Rhodes, a suburb within twenty kilometres of the central business district, in a plant originally built and operated by Colonial Sugar Refineries but bought by ICI Australia shortly before the explosion occurred. During a maintenance shutdown sparks from a cutting torch ignited spilt hydrocarbons in a bund, and the fire travelled up the vent pipe, igniting the tank contents. The tank had corroded around the bottom weld, so the whole tank lifted from its base, spilling burning hydrocarbon, and killed five workers.

The second was in 1990 at St. Peters, an inner suburb, about ten kilometres from the central business district, where the first LPG distribution terminal was built in the 1950s. Ironically, on the evening of April Fools Day an LPG leak ignited, and as the installation was unattended the fire became quite extensive before the Fire Brigade arrived. One tank flew northwards into the river, in a classic boiling liquid vapour cloud explosion (recall my remark about “the lucky country”?), instead of southwards across the street into houses, so no-one was injured. The whole incident was broadcast live, in excellent colour, on television.

The third to be noted was more recent, in July, 1998, and occurred at a small solvent re-refining plant at Wilberforce, which is an outer suburb, more than thirty kilometres north. The plant was unattended during evenings and weekends, and stored all its raw, to be re-refined, materials and products in a relatively small yard behind the factory. A fire started in the yard, contents of drums ignited and drums began exploding. Some travelled fifty metres into other properties. This was also televised, briefly, and the author visited the site a few days later and found it had been completely destroyed. Although it was given prominence in a locally circulated paper there was only half a dozen lines in the major Sydney daily.

At this point we can review what has come from those three events. There was a coroner’s inquest from the first because there were fatalities, but there has been no public comments, the only perceptible result being a tightening of clearance procedures within the company. The second generated a formal enquiry, which criticised management and the company was fined, but the only overt follow-up has been demolition of the terminal and its replacement in a better location. The third has caused no observed action at all.
We can also review the companies. The first has, actually, an excellent safety record even though it uses both hazardous materials and processes, and the event which occurred was quite surprising. The third company was investigated in doctoral research by the first author and was assessed as being higher-than-reasonable risk. A common factor between the first and third was a recent change of ownership of the operating plant. The second company had already had the explosion at Cairns, only a few years previously, and our analysis suggested the company’s profile did not suit its entry into the LPG business.

What follow-up might be expected in other parts of the world? Admittedly, these events do not match the magnitude of Flixborough, Milford Haven, Seveso or Pasadena (Texas), but with the apparently increasing local frequency, and observation of other major accidents in other parts of the world, one could have imagined some strenuous action might have occurred to ensure nothing else happened, particularly nothing bigger.

THE FOURTH EXPLOSION THAT ROCKED SYDNEY
So we come to the fourth explosion, which actually occurred in Victoria and “rocked” Sydney by its economic impact. This was the “big one”, like the severe San Francisco earthquake.

On 25th September, 1998, a major fire with explosions occurred at Longford, some two hundred kilometres east of Melbourne, in the plant where Bass Strait crude comes ashore and natural gas is separated out and piped all over the state. There was two fatalities and considerable property damage within the complex. Victoria was without gas for more than two weeks, at the end of winter, which was serious because the state had become strongly gas-oriented over several decades. Many factories had to close, workers were stood down, the fortunate ones being forced to take annual leave. Many families were unable to cook food and heat water, and had to endure low temperatures for weeks.

Although the major impact was in Victoria Sydney was affected because we have an industrial market with what may be a curious characteristic. Our consumer market is small, so many industries are in only one city to get economy of scale, and goods are shipped between cities rather than have parallel producers. Thus, with Victoria shut down supplies from Melbourne did not go north to Sydney and Brisbane, and west to Adelaide and Perth, and those other cities could not ship south and east to Melbourne because factories there were not operating. Losses were also suffered, of course, by transport companies. A simplistic explanation, but sufficient to illustrate the problem caused by loss of the one gas producer in the south.

We have by now had the report from the commission which investigated the incident. The commission determined that management sins of omission and commission had lead inevitably to what happened. The company’s management has blamed the workers, which lead the first author to have a letter published in our major daily newspaper, comparing doctors (who are said to bury their mistakes in the ground) with managers (who can bury their mistakes in the organisation structure).

History, as outlined above, has shown that government reaction to process safety is retrospective and kneejerk, occurring only after something happens, then depending on media coverage, but losing its appeal rapidly as time passes. In fact, process safety is overshadowed by occupational safety issues. The chemical industry has always lived with technical risk, but
there is now a parallel political risk: the Victorian Premier is threatening industry with a new watchdog armed with sharper teeth and opening the gas industry to competition.

We are left with the question: how did that “big one” come to happen, with all that’s gone before? The answer to that question can be deduced by review of some local factors.

AUSTRALIAN REGULATION OF THE HAZARDOUS INDUSTRIES
The National Occupational Health and Safety Commission (NOHSC), known as Worksafe, is the governing body for process safety and has published a standard, NOHSC 1014 (1996), and a Code of Practice, NOHSC 2016 (1996), with the objective of preventing, and minimising the effects of, any major accidents. These cover identification and classification, reports, training and education, emergency planning, responsibilities, community information, security, and confidentiality of information. However, these are only advisory.

In parallel, each state has an Occupational Health and Safety Act, a Dangerous Goods Act, and Environmental Protection Act, each with relevant regulations, which are principally interested in conventional occupational safety and environment protection. Breaches of the provisions of these acts and regulations can, of course, lead to prosecution. New South Wales also has a Department of Urban Affairs and Planning which has issued a series of advisory papers on hazardous industry planning, very good, but strictly advisory guidelines (so titled).

There is minimal consultation and co-operation between government and industry on process safety issues. The only relevant industry body is the Plastics and Chemical Industries Association, but that is publicly invisible and its initiative, titled “responsible care”, is principally concerned with requiring members to promote and conduct their businesses in ways which protect people and the environment, and ensure a sustainable industry.

We (Di Giunta and Pasad, with Ward) have compared our conditions with those existing in the UK and USA, and we summarise those as follows. The present UK legislation is prescriptive, requiring adherence to specific standards which set out compliance requirements for manufacturers, and is controlled by the Health and Safety Executive. The USA system is non-prescriptive and operates via two separate but related bodies: the Occupational Safety and Health Organisation regulates industrial safety, and the Environmental Protection Administration deals with protecting the environment and the public. Though different in approach both have powers to control companies which do not comply with the appropriate regulations. On the contrary, the Australian system is advisory only.

RECENT RELEVANT OBSERVATIONS
In 1992 the first author (Ward, 1994) surveyed management practices in the chemical industry by requesting over ninety firms to complete a survey, and obtained thirty-one responses. The conclusion was that a large proportion of firms do not want to be publicly examined.

In 1998 the second author was member of one of the groups of senior students who visited nine chemical firms to perform occupational safety audits, and included a brief coverage of process safety issues. None of the firms were found to be more than slightly interested in process safety matters; occupational safety was seen to be receiving much more attention.
PROFESSIONAL REPRESENTATION
The national body representing professional engineers, the Institution of Engineers, Australia, shows, at present, strong interest in sustainability and related environmental issues, with some interest in occupational safety expressed in a policy statement, and although the bookshop handles AIChE publications there is no expressed interest in process safety. The parallel body, the Association of Professional Engineers, Scientists and Managers, Australia, is almost totally interested only in awards and related employment matters. With no body such as the UK Institution of Chemical Engineers, or the USA American Institute of Chemical Engineers and the Centre for Chemical Process Safety, there is no professional organisation to hold the industry and its engineers to the level of interest in process safety seen in the other.

CONCLUSIONS
Several years ago Kletz (1978) wrote a paper suggesting certain accidents follow an inevitable pattern. From our knowledge of previous similar, but smaller, incidents we could have predicted the Longford explosion. But the reason why that occurred is because what we have as process safety standards are only advisory and there is no compulsion, or self-regulation, for industry to comply with those standards. The regulations which exist are only applied with penalties if someone is killed or if there is serious environmental damage.

We need non-prescriptive, results-oriented, legislation backed by educational institutions and professional organisations. Formation of a body similar to the US CCPS is desirable.

If technical risk in the industry continues as at present, political risk to the industry will surely increase, as has appeared in Victoria. We also see political risk to State and Federal governments: if nothing follows from the recent incident, lobbying by public interest groups could influence voting preferences at elections in the near future.

ACKNOWLEDGMENT
As first author of this paper I sincerely acknowledge the research of the students I supervised, Angelo Di Giunta and Sushil Prasad, who provided much of the background content.

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MULTI-FUNCTIONAL DEEPSHAFTS

Han C.M. Breek\(^1\) and Pieter van Donkelaar\(^2\)

ABSTRACT
Modern society faces many problems caused by the density of human activities on small surface areas. As it is difficult to change the two-dimensional surface maps of existing cities and overpopulated areas, the only way to alleviate these problems is to use the third dimension by either going higher up into the air or by going deeper down into the soil.

This paper describes an elegant construction method to do the latter by creating shafts of up to 12 m inside diameter and 80 m depth. The method is vibration-free so that it can be applied close to existing buildings. It is also possible to construct these basins under water in canals or rivers and off-shore.

They have been used to house very compact and efficient water purification plants, as emergency spill basins and as starting pits for horizontal tunnels. Other applications presently under study include automatic car parkings, foundations for off-shore windmills, firewater storage, emission buffers, CO\(_2\) dissolution plants and for retrievable radio-active waste storage at existing sites of nuclear power plants. The shafts can also be used as foundation for buildings.

Multi-functional applications offer important cost savings and additional efficiencies.

INTRODUCTION
The world’s population increases rapidly and much of this growth will be in ‘megacities’ of more than 8 million inhabitants. In all of these cities there is an acute lack of surface space, which causes many problems and risks. Underground construction alleviates this pressure but current building methods are messy and increase the already existing traffic chaos. Our paper describes a method which overcomes these problems.

THE METHOD
The method was developed by VERSTRAETEN bv, Oostburg-NL from existing foundation technology with which this firm has substantial practical experience world-wide (br, re).

Reinforced concrete elements are used to build a first ring in a shallow building pit of between 1 to 2 m depth. The bottom of this ring remains open so that a hydraulically driven cutter can remove the ground in the center of the ring as shown in Figure 1. Simultaneously, water is pumped in to maintain a water level inside of the ring to be always higher than the groundwater level outside of it. The slurry of soil and water is removed by a pump and is then separated again into water and soil by a desander. Because of the higher water level inside of the shaft, the existing pressure equilibrium of the ground is not disturbed. The shaft is installed in series of six steps as per Figure 1.

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APPLICATIONS

VERSTRAETEN shafts have already been used in a number of applications and several more are presently being considered (do). Literature about these applications is included in the bibliography. There is a very keen interest in ‘clean’ underground construction methods, especially in countries such as the Netherlands with a very high population density and suitable soft soils. Many over-populated areas around the world are situated at or near river deltas with similar suitable characteristics.

Foundation

The deepshafts were derived from existing foundation technology and can thus be used as foundation.

Water purification

The first application of deepshafts was for very compact ‘multi-reactor’ water purification systems showing high energy efficiency and low running costs.

Emergency spill basins

The EU Seveso II-Directive will be enforced in the coming years. It requires to prevent polluted fire fighting water from entering the environment. This will necessitate the installation of adequate retention basins (ve,do).

Building pits

The SHELL Company has pioneered the usage of deepshafts, one of them off-shore, as building pits for various purposes. An underground flower transport system presently planned to be installed between Aalsmeer-NL and Schiphol-NL-airport will require a large number of these pits. Several other similar projects are in the pipeline in the Netherlands and Belgium.
Ultra-deep water modeling
The marine hydraulieal test facilities of MARIN, Wageningen-NL have recently installed a 5 m diameter and 30 m deep pit for ultra deep water modeling of oil drilling equipment.

AUTOMATIC UNDERGROUND CAR PARKINGS
Figure 2 shows a project for deepshaft automatic parkings, five of which are planned to be installed in the old city centre of Delft-NL. This features a circulating car storage system for fast retrieval. There is a large demand for efficient underground parkings requiring minimum surface space. Such parkings could e.g. be installed in the canals of Amsterdam-NL, eliminating all visibly parked cars from its beautiful city centre.

OFF-SHORE WINDMILLS
EU DGXVII has announced plans to install 10,000 MW capacity wind turbine generators in Europe and the Dutch Government wants to build 100 turbines of 1-1.5 MW capacity each off-shore. Turbines of larger capacities are also planned. Deepshafts can be installed off-shore and would provide excellent foundations for such large mills.

FIREFWATER STORAGE
Many megacities are located in earthquake-prone areas. If an earthquake strikes, the resultant chaos and broken waterlines prevent effective fire fighting to quell beginning fires. As a result, most of the damage is not caused by the quake itself but by subsequent fires running unchecked after the quake. To prevent such disasters requires earthquake-resistant underground reservoirs for fire fighting water.

EMISSION BUFFERS
Chemical and other companies have to comply with strict effluent emission limits and must pay heavy fines if they exceed them. The installation of effluent buffers in the form of deepshafts prevents these incidents ... and the fines.
CO$_2$-DISSOLUTION
Off-shore wind-driven CO$_2$ dissolution plants based on the multi-reactor principle can bring large amounts of CO$_2$ into deep seawater for long-term storage (do).

RADWASTE
World-wide, there is increasing support for underground storage of radioactive waste in monitorable and retrievable fashion, both from pressure groups and from Government agencies (do). Deepshafts at the sites of nuclear power stations could provide the required space for these retrievable storage systems.

OTHER STORAGE
Many other things can be stored in the safe environment of an earthquake-proof underground deepshaft, where there is no sunlight, no air pollution, a constant temperature and high security.

MULTIPLE APPLICATIONS
Some of the applications as listed above can be combined in one shaft or in a ‘cluster’ of shafts. This reduces cost greatly.

CONCLUSIONS
Multi-functional deepshafts can be used in a large number of applications and in combinations thereof. They could make a significant contribution to reduce risks in fast growing metropolitan areas where space is scarce and expensive. The construction method is elegant and clean and does not disturb or hinder the normal flow of activities in cities and factories.

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THE INFLUENCE OF METEOROLOGY ON PROBABILISTIC NUCLEAR ACCIDENT CONSEQUENCE ESTIMATIONS IN THE LONG-RANGE

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ABSTRACT
An analysis of the influence of the meteorological record employed in probabilistic estimations of long-range impacts of nuclear accidents is presented in this paper. To this purpose accident impacts of the Kozloduy nuclear power plant in respect to Greece are used as the reference case. To estimate the influence of meteorology on long-range impacts different meteorological records are employed, together with a characteristic major nuclear accident that is postulated to occur. This accident is classified as level 7 on the International Nuclear Event Scale and involves significant releases of radioactive materials into the environment. The analysis is focused to the larger 1000 MW unit of the plant, and typical countermeasures are simulated. Consequence estimations are performed by the MACCS2 code, which performs probabilistic calculations of potential offsite consequences of the atmospheric releases of radioactive material in reactor accidents. The results of the analyses indicate that the influence of the meteorological record on long-range impacts is relatively small. A direct outcome of this conclusion in the absence of a site meteorological record is the possibility of using a substitute record in long-range probabilistic consequence analysis of nuclear accidents.

INTRODUCTION
The Kozloduy nuclear power plant (KNPP) is located near the northwestern borders of Bulgaria with Rumania by the river Danube, and includes six operating pressurized water reactors of the VVER type, four with a power rating of 440 MW and two with 1000 MW. KNPP is closer to Greece than any other nuclear station at a minimum distance of 225 km from the northern borders of the country, and a maximum distance of 980 km from the southern coast of Crete Island. To estimate the influence of meteorology on long-range impacts the KNPP site wind rose is employed, together with widely different meteorological records, some of which do not even belong to sites within the region of investigation. In the analysis, a characteristic major nuclear accident, classified as level 7 on the International Nuclear Event Scale(1), is postulated to occur in one of the two larger 1000 MW units of KNPP. Consequence estimations were performed by the latest version of the MACCS2 code(2), which performs probabilistic calculations of potential offsite consequences of the atmospheric releases of radioactive materials in reactor accidents. MACCS2 describes the progression of the radioactive cloud released from the reactor in the event of an accident and predicts its interaction with and influence on the environment and human beings.

ACCIDENT DESCRIPTION AND COUNTERMEASURES
The PWR accident scenario considered and the corresponding source term employed were based on a representative release category characteristic of the US Sequoyah nuclear power plant. This accident is part of a spectrum of possible containment failure modes(3,4), and
corresponds to a very early containment failure during core degradation. It implies serious releases of radioactive materials into the environment. The accident was postulated to occur in one of the 1000 MW Kozloduy units. Economic and health impacts were estimated only for Greece and the Greek population, and the analysis did not extend to areas outside the Greek territory.

Concerning mitigation of doses by emergency response actions the following assumptions were made:

- Food disposal of heavily contaminated foodstuffs was applied based on the USNRC protective action guides, (a) for the growing season pathway for both milk and non-milk crops, the corresponding calculations being performed by assuming that the accident occurs in the middle of the growing season and that the maximally exposed individual will not be exposed to a whole body effective dose equivalent exceeding 0.05 Sv or 0.15 Sv to the thyroid, and (b) for long-term agricultural production, the calculations in this case being performed under the assumption that the accident is equally likely throughout the year, and that the whole body effective dose equivalent to the maximally exposed individual will not exceed 0.005 Sv or 0.015 Sv to the thyroid as a result of an infinite exposure period.
- No evacuation was considered anywhere in Greece.
- Relocation was considered with the following criteria: (a) for the early phase a hot spot relocation dose criterion of 0.5 Sv and a normal relocation dose criterion of 0.25 Sv, i.e. a 0.5/0.25 Sv dose to whole body in one week triggers relocation, and (b) for long-term phase relocation a whole body dose criterion of 0.06 Sv, based on a 0.02 Sv dose for the first year after the accident and 0.01 Sv dose for the following four years.
- Decontamination of land was considered additionally based on two levels of decontamination policy(5).

The original meteorological record used in the analysis, is a record that is representative of the meteorological conditions prevailing in the Greek territory. This choice was made necessary by the absence of a site meteorological record that would be more appropriate.

**RESULTS OF THE ANALYSIS**

The question arising with respect to meteorology is how the meteorological record influences impacts. To this purpose besides the original meteorological record six additional records were employed as follows:

- a second meteorological record representative also of the meteorological conditions prevailing in the Greek territory (GR-2)
- a meteorological record representative of the meteorological conditions at the Surry NPP in the USA (SURRY)
- a meteorological record representative of the meteorological conditions at the Savanna River site in the USA (SAV-RIV)
- a meteorological record representative of the meteorological conditions at a New York site in the USA (NY)
- a meteorological record employed in the sample problems that accompany the MACCS code package (M-REF), and
- a meteorological record used in the NEA/OECD-EC second international comparison of probabilistic accident consequence assessment codes (NEA-BE)
Some of the health and economic impacts of the 1000 MW Kozloduy unit with the employment of different meteorological records are presented in Table 1. The "original file" column contains the original results. The next six columns present the corresponding results that were estimated with the six additional meteorological records previously mentioned.

The last column of Table 1 presents the range of the values of these impacts with respect to the original file values. It is apparent that in all cases the estimated health and economic impacts are similar, varying for most of the impacts within a range of 0.5 to 1.5 in relation to the base case results, even when records from quite a different region are used. It is noteworthy that the larger divergences from the original file values are produced most by the meteorological records of regions quite different then the region under investigation, i.e. by those records that belong to US sites. On the other hand the employment of the other two "European" meteorological records, i.e. the GR-2 and NEA-BE records, results in smaller differences.

CONCLUSIONS
The small variation of estimated impacts when using different meteorological records that is indicated by the results of Table 1 implies that in the absence of a site meteorological record, the employment of a substitute record for estimating impacts in long-range probabilistic consequence analysis of nuclear accidents is well founded. This conclusion is very useful, since in many instances a site meteorological record, even if it exists, is not readily available to third parties. In such a case the use of another meteorological record, especially of a site as close to the region of analysis as possible, is reasonable and it produces acceptable results.

REFERENCES
Chemical industry and certain installations for energy production are characterised by the processing, handling and storage of large amounts of intrinsically hazardous materials. Most of these substances are flammable and, even though there are a number of standards and codes, which specify the safety measures to be taken, a certain degree of risk always exists. In fact, the frequency of large fires in these industries and in the transportation of hazardous materials has increased in the last decades.

From the point of view of fire control, the knowledge and modelization of fire evolution is essential. Although some experimental work has been done, poor information is available on the distribution of flame temperatures with space and time.

This work describes the results obtained on flame temperature distributions from pool fires up to 13 m². Three pool diameters were used (1.5 m, 3 m and 4 m) and two fuels (gasoline and gas-oil) in the different tests. The temperature was measured on diverse points in the axial and radial direction inside the flame. All these data was treated and controlled by a computer using the LabVIEW application. Fieldpoint data acquisition modules were also used.

Finally, a set of conclusions are derived from the experimental data.
One of the main problems of local administration is the problem of risk reduction and risk management on territory of the city. The result of this activity is directly related to economic and social development of region.

The administration of Sosnovy Bor city develops a technique of the collection and accumulation of the information for the analysis and establishment of risk cadastre for the last few years.

The problem of risk management and establishment of risk cadastre can be done on the best all new information on Environment, computing means of information processing and advanced network of telecommunications. Let’s consider 3 mentioned components for establishment of risk cadastre.

The main information resources of the risk analysis risk include:
- cadastre of potentially-dangerous facilities in the region;
- the register of the population living on the territory;
- the on-line data information of a radiation monitoring;
- the on-line data information of the city population;
- the legal base.

Cadastre of potentially-dangerous facilities in the region include detailed description of chemical and radiationally dangerous industry which located in the territory of administrative management and have the following structure:
- general information about enterprises and their properties;
- short naturally-climatic characteristic of the industry location district;
- shot description of the practice and the information, balanced scheme of the material flows;
- the information on using land resources;
- the characteristics of raw material and energy resources used in the process of production;
- the characteristic of waste;
- the characteristic of water consumption and water disposal;
- the characteristic of effluent into atmosphere;
- the information on retreatment of the ground;
- the information on industry transportation.

First of all we draw up an inventory of the facilities which are rather dangerous for environment. Further the description of the facilities as the sources of unfavourable chemical and radiation influence environment and population of 30 km zone are carried out. Incidentally the facilities on characterised from 2 points of view. First as a potential sources of accidents i.e. extreme situations connected with discharge of chemical dangerous substances and appearance of lump-sum superadmissible radiation influence. In the second place as the facilities of badly influence environment at normal condition of exploitation i.e. the really existing radiation situation in the region is described (summary valuation of the industrial discharge and the valuation of each facility industrial discharge individually).
The characteristic of effluent into atmosphere represents the composition, qualitative and quantitative contents of the contaminants containing in the effluents of the industry as well as the information on emergency effluents of the contaminants into atmosphere.

The characteristic of the water consumption and water disposal, conditions of water treatment constructions represents volumes, specific standards composition qualitative and quantitative contents of contaminants in sewage's of industry as well as the information on emergency discharge of contaminants including the contaminants into the soil, water objects, waste-water disposal system, individual capacities.

The working out of ecological passports of city industry is the first stage of potentially dangerous facilities cadaster’s creation.

Cadastre of potentially dangerous facilities connected with the register of urban industry. The urban register of the industry is collecting and processing in the urban administration on the basis of entering information from municipal registration organisation, statistics services and enterprises. The register of urban industry is done with using of “client-server” technology and software Microsoft SQL.

The important component for establishment of risk cadastre is the register of population living on the territory. Now the administration of Sosnovy Bor city is collecting and processing databases on the population living on the territory. The information on residents enters from urban services answering for registration of population. Further it accumulates with employment of special program complex in one database. The program complex is based on the modern “client-server” technology.

It's necessary to have information on quantity of residents in theirs at morning and night – time for more corrective a valuation (with consideration of working time).

For receiving information on radiation situation in the district of nuclear industry complex of Sosnovy Bor city the network of radiation monitoring stations is used. Computer complex included the special controller modem and software. Entering information as a testimony of 6 permanent transducer coming to administration switched channel. The number of questioned transducers and order of questioning is determined by program installation. This data keeping in the computer and formed database of everyday information on radiation situation in the city. The structure of information has the next side:

- number of transducer;
- location of transducer;
- data and time of measuring;
- testimony of transducer.

The problem of risk valuation is usually divided into two subsystems:

- the risk (account of ) chemically dangerous enterprises;
- the risk (account of ) radiationally- dangerous technology.

The description of this subsystems include mathematical models which describe the source of damage, medium spreading and subjects of influence.

All existing models we can divide conventional in 2 categories: classifying models ( selection models ) and estimation models. Classifying models are initial estimation of environmental condition and as a rule don’t connect with physical processes. Estimation models have
physical base and we can use them for analytical work both on the classification level and on the level of estimation.

For the risk analysis the next models can be used.

1. The account of chemical risks is done with use of the special computer subsystem based on the model of classification and handle priorities risks from large-scale emergency at the technology productions and connected with them industrial productions is the method of IAEA.

2. It is optimal to use the models which recommended by supervision of IAEA on performance of probability determination of 3-level safety for NPP in the system of decision making on estimation of radiation emergency after effect and basing steps of population protection.

3. In the system of influence estimation “source – medium – subject” at normal (non-emergency) conditions we can use the united models MEPAS-type. Their using in the system of decision reception on ecological safety in the region allow to make estimation and prognosis of influence (radiation, chemical, thermal) both facilities of nuclear industry complex and the others industrial sources of ecological risks in the region. The account of chemical risks is done with use of the special computer subsystem. It’s based on application of GIS-technology. Incidentally the digital map of municipal territory and program complex Arcview 2.1 by ESRI firm is used.

Electronic map of the city include the system of thematic layers containing the facilities of the same type.

At this moment such layers are:
- dwelling houses;
- districts of the town;
- reservoirs;
- roads;
- industrial buildings;
- schools;
- kindergartens;
- compartments.

The creation of each layer has aim of visualisation definite information for solution specific problems. The attributive information which is related to the objects keeping in the databases connected with each layer. The possibilities of choosing software GIS allow to make and connect databases with any type and quantity information. The information on risks is a separate layer on electronic map of the city together with connect with it database of attributive information.

The used model is applied to estimate risks for population from large emergency at the permanent technology setting as well at keeping, treatment of dangerous chemical substances their transportation by auto and railway transport, pipe-line or inner water rout. Risks for population from fire, explosions, effluents of toxic substances are considered.

The software for collection and processing of the massages arriving from the citizens is prepared and the information on possible environmental incidents is stored. The system allows immediacy to register, to make the analysis and name the reports on any incidents in city leading to emergency situation which can cause damage environment and citizens.

The system ensure:
- the work of operator in the active mode (with employment of switched telephone channels)
- making and coded of database
- reflection and documentation of information

The system use existent database on citizens and enterprises. The system is based on the system Borland Delphi 3.0 in Windows 98.

The information passing through this channel can be used for effective operation with risk cadastre. It reflects the current alterations in ecological situation in the municipal territory. The full algorithm of quantity risk estimation about the work of some enterprises or difficult situation include the following parts. First of all the full number of possible environmental incidents is installed the risk degree from them is determined by estimate of their probable display frequency and their probable consequences. Further the full risk is determined as a sum of risk from incidents with appointed influence.

For the collections and processing of information the corporate data network is developed. As a basis it uses computer network of administration and urban telephone system. It allows to receive promptly and to process information at risk analysis which formed by different city departments. Computer network is based on the "fast Ethernet " technology with carrying capacity 100 Mb and employment of up-to-date computer equipment. The consolidation of urban enterprises and organisation in corporate data network is realised with the help of router.

In the report the information schemes of the system of risk cadastre construction are indicated, the structure of data links and the structure of an urban corporate data network is shown.
EXPERIENCE OF SAFETY DECLARATION FOR OAO "GAZPROM" GAS TRANSPORTING ENTERPRISES

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ABSTRACT
In the paper there are concisely described the results of the safety declaration procedure (including a quantitative risk assessment) for compressor stations and main pipelines belonging to two different gas transport enterprises in Russia.

The improvement of the social relations regulation system in the field of industry safety is an important point among the first priority tasks of the Russian government. As a main instrument of the regulation the obligatory declaration of hazard industry enterprises safety state was by-law established in Russia since 1995. The safety declaration procedure envisages a quantitative risk assessment for the enterprises followed by insurance of their responsibility to third parties for possible damage in event of accidents.

As an illustration of the safety declaration experience in the Russian gas industry the results of the research of two gas transport objects are given here performed by experts of VNIIGAZ - the company that has already made a good showing in the industrial risk scientific field.

The object «A» located in the Volgograd region includes a compressor station (CS) with four technology chains that work for five parallel main gas pipelines with diameters of 1,200 and 1,400 mm and operation pressures of 5.5 and 7.5 MPa. The pipeline «corridor» length within the object «A» territory is 74 km.

The CS territory occupied 22.3 hectares. The chain No.1 includes six gas turbine centrifugal compressors stationed in a common building. In the chain No.2 there are twelve gas electric compressors placed in another common building. The chains No.3 and No.4 include five and seven gas turbine compressors correspondingly each of these is stationed in a separate light shelter. Besides on the CS territory there are situated 28 gas cleaners of significant volume (10-35 m^3 each), 42 gas cooling apparatuses, 2 lube oil storage facilities, high pressure pipelines of different diameters (up to 1400 mm) with total length of 2000 m. All the equipment creates a threat first of all to the CS personnel (316 persons are usually on the CS territory in the day-time and 14 ones -at night). The CS facilities do not threaten to inhabitants outside the CS because the nearest village is 2.5 km from the CS.

As for the main pipeline «corridor» this one passes through a sparsely populated areas. However, along the pipelines route season agricultural works are carried out in which about 3,500 persons take part from May to September.

The object «B» located in the Nizhniy Novgorod region includes a CS with seven compact gas turbine compressors (placed in separate containers) that work for a main gas pipeline with
diameter of 1,200 mm and operation pressure of 5.5 MPa. Within the CS territory (4.5 hectares) there are 65 persons in the day-time and 5 persons – at night. Besides the object «B» includes a net of main pipelines with different diameters (150-1,400 mm) of total length of 1,100 km situated all over the N. Novgorod region. The pipelines pass through populous areas with intensive agricultural works in which about 10,000 persons take part from spring to autumn.

On the base of real failures and accidents retrospective analysis the following scenarios of failures in compressor stations were selected:

- a rupture of a large diameter buried gas pipeline (joining a CS and a main pipeline) followed by a jet or a «crater» fire;
- a rupture of gas compressor piping (buried or not) followed by a fire;
- a rupture of a vessel (a gas cleaner or a gas separator) followed by a jet fire;
- gas deflagration ignition (explosion) inside a compressor building followed by a shock wave and a fire;
- a lube oil pool fire inside a compressor building.

Main pipelines accident scenarios analyzed in the research work were ruptures of the pipelines followed by shock waves and fires of the following two types: 1) a jet fire occurring as a rule at large diameter pipelines buried in «weak» soil; 2) a «crater» fire occurring as a rule at small diameter pipelines buried in «solid» soil.

So main people-damaged effects of the failure scenarios described are to be overpressure of a shock wave and heat radiation from a fire. To predict the effects and their damage zone dimensions the package of special models and computer codes was elaborated by experts of VNIIGAZ, Lomonosov Moscow State University and Moscow State Construction University. The codes make it possible to predict gas outflow rates from pipelines and vessels, gas jet dispersion, overpressures of gas deflagration fires (explosions) outside and inside, flame dimensions and heat radiation fluxes in natural gas and liquified hydrocarbons burning.

When analyzing main pipelines it is very important to predict the failure rate on a concrete pipeline route leg (situated, for example, near a populated area). The special method was worked out in VNIIGAZ the main idea of which is the correction of the average (over the All Russian Gas Transport System) actual failure rate by means of some coefficients. The coefficients reflect the influence of different local factors (natural, man-made, technological ones) on the failure rate. The coefficients values were obtained as a result of a thorough analysis of pipeline failures occurred in Russia since 1980.

By means of the models and codes there were obtained the following outcomes.

The object «A» compressor station. The fire and explosion rate expected inside compressor buildings is $1.84 \times 10^{-2}$ events per year, outside - $1.97 \times 10^{-2}$, and in total over the CS - $3.8 \times 10^{-2}$ events per year, i.e. an event per 26 years of the CS operation. The overpressure peak value ($\Delta P_{\text{max}}$) inside the chain No.1 compressor building (made of steel-concrete panels with 360 m$^2$ glazing) under gas explosion provided the building is fully filled with gas is predicted of 5 kPa (Fig.1).

$\Delta P$, kPa
Fig.1. Gas explosion overpressure inside the chain No.1 compressor building
(α-gas burning intensity factor)

The $\Delta P_{\text{max}}$ value in the chain No.2 compressor building under the same conditions is 8 kPa. Such overpressure values themselves do not create a threat to a human being since a damage is possible only if the overpressure exceeds 40 kPa. But the values predicted can result to destroying the buildings parts. In this event the percentage of the people damaged who located in the control room and other auxiliary rooms of the compressor buildings (in total twenty persons) is predicted of 2% in the chain No.1 compressor building and 8% in the chain No.2 one.

Under gas explosions in any of the chain No.3 and No.4 compressor shelters the $\Delta P_{\text{max}}$ value is predicted of 37 kPa. The overpressure destroys the shelter completely. The personnel is usually out of the shelters in the control buildings that are situated not closer 50 m to the compressor shelters. Overpressure values near the control houses do not exceed 1 kPa. So the values create a threat nor to the control rooms or to the personnel.

As for ruptures of the CS outward pipelines of different diameters (150-1,400mm) and operation pressures (0.3-7.5 MPa) the overpressure values of shock waves do not exceed 0.9 bar (in the worst event) already at 25 m from the rupture point and quickly decrease against distance. So such effects do not a real threat to the CS personnel.

However in event of the pipelines fires the heat damage zone radii (provided people escape at rate of 2.5 m/s) reach the values of 200-300 m (Fig.2). So just the heat radiation from fires contributes mainly to the CS personnel risk.

The object «A» main pipelines. The specific failure rate for different legs of different pipelines varies from 0.16 up to 0.94 ruptures per 1,000 km per year. The sum failure rate for all the five pipelines with total length of 74.5=370 km is 0.146 ruptures per year. The fire rate provided the relative frequency of gas outflow ignition is 0.65 is predicted of 0.092 fires per year.
Under the risk assessment in relation to population the pipelines intersections with roads and intensive agricultural activity areas were analyzed first of all because there are no localities near the pipelines. The analysis took into consideration the road transport intensity and the time of being the agricultural workers near the pipelines averaged over a year. The integral risk value predicted is 0.0273 lethal events per year, i.e. one death per 42 years. The greater part of the risk falls on the agricultural workers.

**The object «B» compressor station.** The rupture and fire rate expected over the CS - $3 \times 10^{-3}$ events per year that is one tenth of that one at the object «A» CS. The individual risk peak value is predicted of - $1.3 \times 10^{-3}$ near the compressor units, gas cleaners and large diameter pipelines. The integral risk value predicted all over the CS is 0.018 lethal events per year (one death per 55 years) that is one third of the risk value for the object «A» CS. It can be explained by a far lesser quantity of hazard equipment and gas at the object «B» CS.

**The object «B» main pipelines.** The specific failure rate for different legs of different pipelines varies from 0.05 up to 0.08 ruptures per 1,000 km per year. The sum failure rate for all the pipelines with total length of 1,100 km is 0.063 ruptures per year and the fire rate is 0.02 events per year. The average relative frequency of gas outflow ignition is less than that one at the object «A» due to greater part of small diameter pipelines here.

Under the risk assessment in relation to population some populated areas with buildings violated the pipeline proximity regulations were analyzed first of all and then - the pipelines intersections with roads and intensive agricultural activity areas. The integral risk value predicted is 0.012 lethal events per year, i.e. one death per 840 years. It has been established that the localities violated the proximity regulations and the transport intersections mainly contribute in the risk. As the result shows the risk value is one twentieth of that one for the object «A» that is conditioned by the following points: 1) lesser diameters and operation pressures of the «B» pipelines; 2) more favorite climatic and soil conditions with point of view of pipe corrosion in N.Novgorod region compared with Volgograd region; 3) higher level of the pipeline maintenance at the object «B».
IN CONCLUSION of the research there were proposed some recommendations to decrease the risk both in the object «A» and the object «B». Specifically it was recommended to transfer some localities further from pipelines, increase prescriptive transport speed values at the road legs crossing the pipelines, transplant along the pipeline routes the crops which do not require many workers for their planting, care and harvesting.

BIBLIOGRAPHY

PROCEDURES FOR RISK ANALYSIS OF PIPELINE NETWORKS

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ABSTRACT

Process plants often require pipeline networks in order to provide burners and other process equipment with miscellaneous flammable gaseous compounds. Pipeline networks containing flammable gaseous compounds may be considered a relevant risk source. Moreover, the consequence analysis of accidents caused by these devices is complex, due to the wide extension that these networks may have inside process plants and thus to the high number of locations where accidents may take place.

The present study focuses on the consequence assessment of accidental events due to confined explosions. Among the major hazards caused by confined explosion in pipes containing flammable gaseous compounds, particular attention was devoted to fragment projection, mainly because missiles have the potentiality of starting knock-on accidental scenarios.

A procedure based on event-tree analysis was developed in order to assess the possibility of accidental scenarios due to fragment projection. Literature models were used to evaluate overpressures caused by deflagrations or detonations inside pipes. Initial velocity and maximum distance of missiles was estimated.

INTRODUCTION

Pipeline networks containing flammable gases are often present inside process plants. These pipe systems cause hazards that are common to all vessels and pipes containing gaseous flammable compounds. However, the characteristics of pipeline networks make more complex the analysis of accident consequence due to the wide extension that these networks may have inside process plants and thus to the high number of locations where accidents may take place.

Besides the hazards due to the release of flammable gases, that are common to all pressure vessels containing flammable compounds, pipeline networks may undergo accidents due to confined explosions, in particular as a consequence of maintenance operations.

While the consequence assessment of accidents due to the release of flammable compounds follows well-known and generally accepted procedures, the characteristics of confined explosion accidents make difficult the development of general methods for the estimation of the accident consequences.

This paper focuses on the analysis of confined explosion accidents in pipes. The possibility of these accidents was investigated on the basis of pipe geometry and of the characteristics of the flammable mixture. Particular attention was devoted to missile projection, the consequence of confined explosions in pipelines that is more likely to trigger knock-on accidents.
HAZARD AND OPERABILITY ANALYSIS

Although pipeline networks may have very different features, the hazard and operability analysis usually identifies two typical "top events":

i) the loss of containment and thus the release of flammable gas; and

ii) the formation of a flammable mixture inside pipes due to the entrance of air.

The first top event may be caused by a number of sequences of primary events (corrosion, tube puncture or rupture by external events, leakages through joints, etc.), while the second is likely to be the consequence of maintenance operation or of sequences of primary events that may cause a depressurization of a section of the pipe network.

CONSEQUENCE ANALYSIS

The release of flammable materials is the more common top-event that results from the hazard analysis of a chemical plant. Consequence analysis by event tree methods and models for unconfined explosion and fire follows well-accepted procedures. Several software consequence analysis packages are available. Thus these events will not be further discussed in the present paper.

On the other hand, the consequence assessment of the formation of a flammable mixture inside pipes may be influenced by a number of factors, and thus no standard procedure is available for the evaluation of the effects of these accidents.

The event tree following the formation of a flammable mixture in a pipe is shown in figure 1. The figure clearly shows that the main consequences of the event may be missile projection and fire following the rupture of the pipe, that is likely to take place in correspondence of a welded joint or of a valve.

Thus the attention was focused on the consequence assessment of missile projection following a confined explosion inside the pipe, since the consequences of fire are similar to those assessed as a consequence of the loss of containment.

<table>
<thead>
<tr>
<th>ignition?</th>
<th>pipe rupture?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Y</strong></td>
<td></td>
</tr>
<tr>
<td>** Formation of Flammable mixture**</td>
<td>combustion and pressure wave</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>no relevant consequence</td>
</tr>
<tr>
<td>** Y**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>missile projection</td>
</tr>
<tr>
<td>** N**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>no relevant consequence</td>
</tr>
</tbody>
</table>

Figure 1: Event tree following the formation of a flammable mixture in a pipe

The possibility and the effects of missile projection are determined by the pipe geometry and by the characteristics of the confined explosion following the ignition of the flammable mixture inside the pipe.
CONFINED EXPLOSION

It is well known that the ignition of a flammable mixture may result in two different phenomena: deflagration and detonation. The overpressures originated by these two combustion modes are quite different, the overpressures due to detonation being up to an order of magnitude higher than those due to deflagration.

Thus the first important point to assess is the combustion regime inside the pipe. In fact, while detonation in an unvented pipe is likely to cause the collapse of the pipe and missile projection, the overpressure due to deflagration may not be sufficient to cause the pipe rupture. Figure 2 shows the event tree for missile projection following a confined explosion. The pressure of the combustion wave due to detonation (the Chapman-Jouguet pressure $P_{CJ}$) may be easily estimated using well-assessed softwares [1]. On the other hand, since in a long pipe the adiabatic assumption used for the calculation of deflagration overpressures seems unrealistic, the pressure due to deflagration should be calculated solving the energy and mass balances for a combustion and pressure wave travelling in the pipe in the deflagration regime. A computer code was developed within the present study for the evaluation of deflagration overpressure peaks within a pipe. The burning velocity resulted the more critical parameter in the model. However, for a coke-gas stoichiometric mixture deflagration overpressures resulted of less than 0.5bar for burning velocities up to 10m/s, while $P_{CJ}$ resulted of 18bar. This suggests that in the absence of a detonation, deflagration inside pipes is unlikely to cause
severe consequences. The event-tree in figure 2 shows that all the conditions required for the direct onset of a detonation are usually fulfilled for pipes with diameter higher than 1", with the exception of the condition on the ignition energy. The high values of ignition energy required make unlikely the direct onset of a detonation. Thus, the more likely mechanism for a detonation inside a pipe is the deflagration to detonation transition (DDT). A rough estimate of the distance necessary for DDT may be obtained from NFPA 68, where the maximum distance between the detonation venting devices is given.

A detonation or a deflagration resulting in a pressure exceeding the project pressure of the pipe result in pipe rupture. This is more likely to take place in correspondence of tube bends, curves, or valves due to the effects of the reflected pressure wave. Pipe ruptures causing missile projection should thus be expected mainly in correspondence of welded joints of curves or valves.

The effects of missile projection may be calculated by literature models. Several are reported by Lees [1]. The model of Baum [2] proved to be the more effective, relating fragment initial velocity to the internal pressure of pipe when rupture takes place. The maximum distance of fragment projection may be calculated by the model of Baker [3]. Table 1 reports some results obtained for coke gas pipes inside a steel production factory.

<table>
<thead>
<tr>
<th>external diameter (mm)</th>
<th>spessore (mm)</th>
<th>fragment mass (kg)</th>
<th>$P=5$ atm</th>
<th>maximum impact distance (m)</th>
<th>$P=18$ atm</th>
<th>maximum impact distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>fragment initial velocity (m/s)</td>
<td>maximum impact distance (m)</td>
<td>fragment initial velocity (m/s)</td>
<td>maximum impact distance (m)</td>
</tr>
<tr>
<td>813</td>
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<td>1366</td>
<td>29.0</td>
<td>76</td>
<td>69.8</td>
<td>350</td>
</tr>
</tbody>
</table>

Table 1: Ranges of missile projection for different rupture pressures of typical 90° curves for different pipe diameters

CONCLUSIONS

Missile projection resulted among the more hazardous consequences of confined explosions in pipeline networks. Even if overpressures generated by deflagration may not be sufficient to cause tube rupture, the possibility of DDT should always be considered. Damage ranges up to 500m, depending on pipe diameter and pipe project pressure, should be considered in consequence assessment.

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PROBLEMS ON SAVE OF OFFSHORE BLACK SEA GAS TRANSPORT PIPELINES

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The Black Sea is characterised by some problems which may block long distance gas transport from Russia to Turkey. Some of them are as follows:
- large depths, about 2 kilometres,
- high concentrations of H₂S and other corrosion agents in the sea,
- high pressures.

Low-alloyed steels used for gas transport pipelines are very sensitive to sulfide corrosion cracking, especially high strength steels (grades X60-X100). Carbon steels have better resistance to SCC than low-alloyed ones. However, their strength properties are insufficient for transporting large amounts of gas from Russia to Turkey.

Recent estimations of Solatrach specialists for economically advantageous transport of gas from Algeria to Spain and to Italy have resulted in the following data: minimum 14 billion cubic meters per year. Gas is cheap. However, its transport costs much. The building of 1 kilometre of offshore gas transport pipeline from Algeria to Spain and to Italy costs 2.5-3 million dollars.

STAINLESS STEELS, Ni ALLOYS, Ti. English standards recommend to use superaustenitic, superduplex, and superferritic alloys with high pitting resistance equivalent \( \text{PRE} = \%\text{Cr} + 3.3\%\text{Mo} + 16\%\text{N} \). High content of Ni prevents stress corrosion cracking. Other materials are used to prevent marine corrosion: Ti alloys, different composites, plastics. In the North Sea, they used combined method of corrosion prevention. Ti alloys are used for submarines.

Russian officials refused to use large diameter 1420 mm pipes for the Black Sea because of the size effect that has been investigated in many works of the author. They are planning to use either two 900-1020 mm pipes or several 400-500 mm diameter pipes with large thickness.

Another problem is the absence of hard bottom in the Black Sea. The bottom consists of sulfide corrosion products.

DISTANCE EFFECT blocks gas transport from Russia to Turkey across the Black Sea.

THICKNESS EFFECT: The risk of obtaining a brittle thin-wall material is much lower than that of obtaining a brittle heavy-wall materials.

HYDROGENATION EFFECT. Hydrogenation occurs during corrosion and for hydrogenated surface a crack of any length may be critical (4-19).

SCALE EFFECT. The increase of the diameter of a pipeline results in the decrease of fracture time and the increase of the length of the fractured zone.

The use of superstainless steels for the Black Sea offshore pipelines will be astronomically expensive. However, corrosion resistance of simple steels and materials is not sufficient.
Specialists of the Swedish firm Sandvik have recently proposed the superduplex steel 2507 for the Black Sea offshore pipelines.

Table Chemical composition of superduplex stainless steel 2507

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>Other elements, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 0.03</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>

All these effects have been reported to exist in pipeline made of low-alloyed or carbon steels. For stainless steels the situation is the same.

Corrosion resistance and mechanical properties of supersteel 2507 in sea water are good. But large diameter gas pipelines made of this steel have never been used.

So fracture mechanics experiments or full-scale tests must be conducted before building the Black Sea offshore pipeline and its operation.

The profile of the Black Sea bottom was discussed earlier.

CATHODIC PROTECTION. The Earth civilization has not built cathodic protection systems which can control and provide necessary cathodic protection currents along 400 kilometres of the route at the sea depth of 2000 meters. Additionally high cathodic protection potentials result in hydrogenation. Sometimes anodic hydrogenation occurs.

Repair technologies have never been used in such conditions.

Nowadays there are no data suggesting optimism on safe operation of offshore the Black Sea gas transport pipelines.

CONCLUSION

Nowadays there are no data suggesting optimism on safe operation of offshore the Black Sea gas transport pipelines. Certainly such gas pipelines will fracture many times. The Black Sea ecology would suffer greatly.
FORECASTING THE DISASTER RISK BY PROBABILISTIC ANALYSIS OF NATURAL PHENOMENA

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For management of natural risks at urbanized areas long-term forecasting and emergencies is required. However, the efficiency of solutions taken in the process of management substantially depends on prognostic accuracy. To improve the accuracy, together with the statistical data on reiteration of natural phenomena, mathematical models are to be applied. It is quite obvious that the dependence of parameters whose deviation from the standard values characterize the intensity of the natural phenomenon on the time period can be considered to be the conditions for implementation for a sufficiently long period of time, the intensity of adverse natural phenomena at a certain location can be calculated. However, the accuracy of frequency assessment of seldom-occurring extreme natural phenomena is low, the latter resulting in insufficient accuracy of disaster forecasting.

Modelling of adverse natural phenomena as a throw-out of randomized processes has been purpose. By assessing the realization of a natural phenomenon, its correlation function and spectral density can be determinated. These characteristics make it possible to calculate the mathematical expectation of the number of adverse natural phenomena for the pre-set period as we; as the function of distribution of their amplitudes. The distribution of adverse natural phenomena in time and by their throw-out amplitudes has been studied. Exceeding of the stability of technological entities by the throw-out amplitudes at urbanized territories can result in essential consequences for the population of the above adverse natural phenomenon to disaster. Consequently, the mathematical expectation off the number of disasters at a certain location for the pre-set period of time can be calculated as the product of the mathematical expectation of the number of adverse natural phenomena multiplied by the probability of the technological entity by the throw-out amplitude.

The obtained results can be used by the state and regional administration bodies when elaborating the scenarios of emergency occurrence; planning preventive protection measures as well as investments and insurance.
ON THE ISSUE OF ENVIRONMENTAL SAFETY OF GAS MAINS IN THE OAO GAZPROM SYSTEM

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ABSTRACT
Gazprom is one of the leading gas companies in the world having no analogs both in terms of scale and diversity of its activity. The paper presents the environmental influencing factors dynamics of Gazprom’s facilities, including that of gas transmission network. The gas transmission network and the specificity of its operation are characterised. The paper deals with issues related to atmospheric gas emissions and losses depended on the state of art of equipment and technology employed in gas mains (GM). These issues include atmospheric gas emissions at regular pipeline purgings, incidental losses due to gas leakage resulting from pipeline tightness breaks. The extreme case is a complete rupture resulting from breakdowns due to the loss of GM’s tightness.
Natural gas emission evaluation methods and calculation and experimental data are discussed.
The system of analysis and record of accidents and damages at the linear part of GM is considered, the major causes and dynamics of accidents distribution at GM. Another issue being discussed is the provision of a trouble-free operation of Gazprom facilities due to introduction of the industry’s diagnostic system of GM maintenance and technical revamping with new instruments and technical state control technologies. Gazprom widely employs the machinery of international cooperation and keeps contacts of long standing with lots of business partners. These are works on stress corrosion, inner pipe flaw detection etc. The paper notes the importance of these works and the point that in the coming century the technological decisions not providing the industrial, social and ecological reliability and safe operation of GM facilities would not have the right to be employed.

INTRODUCTION
Gazprom is one of the leading gas companies in the share of which in the domestic production of natural gas amounts to 94% and around 25% in the world natural gas production.

Being the largest company in the fuel-power complex of the Russian Federation Gazprom exerts a certain environmental impact.

The unified gas supply system (UGSS) of Russia is a unique both in term of length and capacity system of gas pipelines.

Environmental safety of gas mains

Along with emission caused by a technological level used on gas pipelines there are accidents which arise due to loss of gas tightness that in certain cases leads to a full rupture of pipes.

The accidents on gas pipelines lead to natural gas emission and soil-vegetation cover damage.
Gazprom thanks to the accomplishment of a corporative environment policy succeeds in reducing the above environmental impact within allowable limits established by Russian laws.

The Gazprom’s environment policy includes the development of power environmental safety programs, effective system for reducing and stabilizing losses and leakage of natural gas and gas pipeline inspection system.

The targets designed for reducing accidents, locating defects and developing systems of technological safety and engineering inspection on gas pipelines are being fulfilled parallel with specific programs developed in Gazprom.

Gas transmission grid of Russia is characterized by some distinctive features. First of all the transmission system is basically made of large-diameter pipes (1220-1420 mm), the percentage of which accounts for 60% or 89 thousand km of a total length. An usual working pressure is 5.6 or 7.5 MPa. 35% of gas mains are being operated at 7.5 MPa.

An average age of the Russian gas pipelines is 16 years. Approximately 30% of them are being operated more than 20 years. 40 thousand km have worked out their designed service life (33 years), while 3.0% of gas pipelines have a service life more that 40 years.

It is obvious that the existing gas transmission system is not perfect. Gas losses occurring because of pipeline failure including holes, cracks etc. are considerable.

Failure inspection system that is used in Gazprom incorporates the following elements: classification of the main reasons; calculation of failure intensity per 1000 km/year; calculation of gas losses and time which is needed to remove an accident; and a number of replaced pipes, etc.

The basic reasons of failures and their distribution are as follows: external corrosion of pipe metal – 25%, stress corrosion – 17%, mechanical defects of operated pipelines – 23%, installation work defects – 21%, and pipes and equipment defects – 14%.

In 1995-1998, the annual frequency of failures on the Russian gas pipelines accounted for 0.18-0.27 per 1000 km. This figure is 1.6 times lower compared to that in Western Europe (0.38-0.6). In USA this frequency is 0.16 and in UK - 1.4 (for offshore pipelines laid in the North Sea).

The analysis of failures shows that the main reason of failures is longitudinally-oriented stress corrosion cracks.

The problem to provide failure-free operation of the Gazprom’s enterprises is solved by the introduction of a gas pipeline inspection system. At present there are the organization structure for performing inspection works and the reliability and forecast estimation scheme in Gazprom.

The control equipment and technologies are periodically replaced by up-to-date ones.
The practice of technical inspection of gas pipelines used both in Russia and abroad includes sophisticated inspection methods. Among them are intelligent pigs which are reliable and effective means for inspecting internal surface of pipes. At present the gas industry are equipped with modern intelligent pigging complexes designed for inspecting gas pipelines of large diameter.

Since 1991, 26.6 thousand km of pipelines have been inspected with magnetic pigs.

The volumes of intelligent pigging are steadily increased.

In 1995-1997, Gazprom under an international program (including the leading gas research institute (VNIIGAZ), foreign companies and independent experts) conducted experimental tests on the evaluation of natural gas losses, location and inventorization of methane emissions and estimation of their volumes during natural gas production and transmission.

Extensive field tests on the remote and contact detection of emissions and on measurement of their volumes on gas pipelines, compressor stations and gas fields have been carried out.

Interindustry specific emission indices for the whole natural gas flow chain were established along with their extrapolation to the entire gas transmission system of Gazprom. Natural gas emission at the Gazprom’s enterprises amounted to less than 1.0% of the total gas transported.

The analysis of gas emission shows in spite of the fact that the level of gas emission at the Gazprom’s enterprises is somewhat higher compared to that in Western Europe this level is lower compared to that published in literature.

Gazprom carries out ecological projects directed to reducing natural gas losses, to decreasing energy efficiency and to cutting fuel gas consumption together with known companies.

The beginning of a new century will be marked by an intensive construction of pipelines including the Yamal-Europe gas pipeline in the existing UGSS energy corridor, South-Europe transit gas pipelines, gas transportation to Balkan region and Turky, unique Black Sea offshore gas pipeline, North Europe transit gas pipeline to Europe through Finland, Sweden and Denmark, and, finely, gas pipelines from the Irkutsk fields in eastern Siberia to China and South Korea. The Sakhalin projects should be also mentioned in this list.

It is clear that all these pipeline systems are to be designed, constructed and operated based on up-to-date technologies in order to provide reliability, quality, efficiency, long service life and environment safety. At the same time one must mind about the decrease of power intensity and installed power per employee on the basis of energy-efficient technologies.

In the on-going century technical decisions not providing industrial, social and ecological safety and reliability of industrial enterprises will be excluded from the modern practice.
THE FORMING OF RISK INDICES TOTALITY WITH HIERARCHICAL STRUCTURE

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ABSTRACT
The paper describes the authors' experience regarding the forming of interconnected risk indices totality which has been oriented towards its application to accidents hazard assessment in the industrial regions. The approach to be proposed allows to construct this totality as a composition with hierarchical structure.

INTRODUCTION
The research activity which concerns the development of regional systems for industrial risk management causes today the necessity to choose a totality of informative cost functions allowing to observe the real state of the population security. So the problem of such totality forming with respect to its perspective utilization in the framework of closed-loop system with different control institutions participation attracts attention of many investigators. The authors of the present paper have dealt with the problem above mentioned during the last five years. Now they can formulate the conclusions important for risk indices (RI) optimal choice realization:

(i) the decision-makers usually need of small number of RI reflecting in maximal degree the situation to be regulated,
(ii) the RI to be used by decision-makers must have simple physical or other sense,
(iii) the analysts who organize decision-making support usually need of RI which cover the real spectrum of hazard sources and which at the same time are of generic type,
(iv) the representatives of industry need of more detailed RI giving them a possibility to fulfil the planning of concrete technological processes with respect to risk limitations.

Some of the noted conclusions seem to be in contradiction. Meanwhile this contradiction can be eliminated in the case when different kinds of RI are used simultaneously and when the whole indices totality has a strict structure.
The main idea to be proposed is to construct such totality as a composition of partial RI with hierarchical structure. The forming of interconnected RI has been realized in relation to the industrial accidents hazard assessment and population security level management in the Republic of Bashkortostan (one of the largest Republics inside Russia with high concentration of petrochemical and oil-refining enterprises, oil and gas pipelines, etc.).

THE BUILDING OF RI HIERARCHICAL STRUCTURE
The resulting structure of RI totality to be proposed is illustrated by Figure 1.
The upper level of this structure is represented by IR which can be directly used in the decision making process. The indices above mentioned look as vectors including the probabilities of accidents possible scenarios and the correspondent consequences. In turn the consequences include three kinds of estimations: the number of probable deaths, the number of people to be injured and the financial equivalent of damage to be expected.
The intermediate level is constructed of RI characterizing separate types of hazardous factors influence measures. The chemical danger, radioactive contamination, the interruption of
human being provision are among the factors which are taken into account by these RI introduction.

At last the lower level is formed of the indices concerned with concrete technological processes, the masses and the types of substances, the numbers of devices with radioactive components, etc.

Let the risk indices of \( j \)-th hierarchical level \((j=1, 2, 3)\) be combined within the vector estimation cost function \( R^{(j)} \). Then the expressions

\[
R^{(3)} = f_1(R^{(2)}), \\
R^{(2)} = f_2(R^{(1)})
\]

where \( f_1, f_2 \) are any functions, can be utilized as a basis for the development of sequential procedures for the hazard numerical characteristics assessment.

The next section contains the description of some versions of the problem caused by the desire to fulfill RI interaction analysis.

**THE TYPICAL PROBLEM STATEMENTS**

It is inherent to consider such problem statements in relation to two kinds of situation concerned with decision-making conditions.

(1) **Situation without uncertainty** (all RI at the levels 1, 2, 3 have been chosen and functions \( f_1, f_2 \) are known).

The typical problem statements look here as follows.
The assessment problem. For each object it is necessary to find $R^{(2)}$ using expression (2), then to compute

$$R^{(3)} = f_2(f_1(R^{(1)})),$$

(3)

After this it is necessary to compare $R^{(3)}$ with correspondent scale in order to determine class $G$ to which the object belongs (in the sense of its hazard degree).

The problems of norms forming. Assume that we know the limitations

$$R^{(3)*}_k(G) \leq R^{(3)}_k \leq R^{(3)**}_k(G)$$

(4)

which reflect the requirements of the object belonging to class $G$ (in the sense of hazard degree).

In inequalities (4) $k$ is a number of vector $R^{(3)}$ component ($k=1,2,...$); $R^{(3)*}_k(G)$, $R^{(3)**}_k(G)$ are the given values.

It is necessary to find the limitations for

$$R^{(2)} = f_1^{-1}(R^{(3)}),$$

(5)

$$R^{(1)} = f_2^{-1}(R^{(2)}) = f_2^{-1}(f_1^{-1}(R^{(3)}))$$

(6)

in order to satisfy (4).

(2) Situation with uncertainty (the interconnections between $R^I$ at different levels cannot be described by deterministic models).

In this case we obtain the following problem statements.

The assessment problem. It is necessary to find any characteristic of random vector $R^{(3)}$ (for example, expectation $M(R^{(3)})$ involving the statistic data on $R^{(1)}$, $R^{(2)}$ and also the distribution functions $F_1(R^{(2)}, R^{(1)})$, $F(R^{(3)}, R^{(2)})$ obtained from experiments.

The problem of norms forming. It is necessary to find limitations for $R^{(1)}$, $R^{(2)}$ such that the probabilities

$$Prob\{R^{(3)}_k < R^{(3)*}_k(G)\}, \ Prob\{R^{(3)}_k > R^{(3)**}_k(G)\}$$

(7)

are less than the given values.

The problem statements above mentioned become a basis for the further organization of risk management within the industrial regions. The experience of the correspondent development of the system for such management in Bashkortostan Republic is described in the monograph [1].

REFERENCES

TRACK 1

SESSION 5

TECHNOLOGICAL RISK – QUANTITATIVE RISK ANALYSIS (2)
The uncertainty problem. For each object $i$ is necessary to find $\theta^{(i)}$ using two separate equations for $\theta^{(i)}$ and $\theta^{(j)}$.

\[ \theta^{(i)} = f_i(\theta^{(j)}) \]

After this it is necessary to compare $\theta^{(i)}$ with an expert judgment made by using the information about $G$ in which the bigger belongs (on the name of its branch degree).

The problem of experts forming. Assume that we know the frequencies

\[ k^{(i)}(G) \leq k^{(j)}(G) \leq k^{(m)}(G) \]

which reflect the object's degree of belonging to the same belief degree $G$.

In inequalities (4) $k$ is a number of cases $\theta^{(i)}$ component ($G$), $\leq$ is between $\theta^{(i)}$ and $\theta^{(m)}$ at the given value $G$.

It is necessary to find the following:

\[ \theta^{(i)} = f_i(\theta^{(j)}) \]

\[ P^{(i)} - P^{(j)}(\theta^{(m)}) \]

in order to satisfy (4).

2. Discussion with uncertainty. The information on between $G$, $\theta^{(i)}$, and for the given degree $G$ is necessary to find the frequencies

\[ k^{(i)}(G) \leq k^{(j)}(G) \leq k^{(m)}(G) \]

and also the distribution function $F(\theta^{(i)}, G), F(\theta^{(m)}, G)$ is required to calculate

Do the two frequencies $\theta^{(i)}$, $\theta^{(j)}$ correspond to the same belief degree $G$?

The problem statements above are agreed (through a weak for the frequency organization of real management within the industrial region). The importance of the corresponding development of the system for management to management at Republic is described in the section (1).

REFERENCES

STRATEGIES FOR THE QUANTITATIVE RISK ASSESSMENT OF KNOCK-ON ACCIDENTAL SCENARIOS

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ABSTRACT
The availability of quantitative procedures for the estimation of "knock-on" hazards is of particular importance for comprehensive industrial hazard assessment in areas where many different hazardous industrial activities are present. This work was aimed to the development of simplified quantitative procedures for the evaluation of hazards due to knock-on accidents in quantitative area risk analysis. The starting point was the definition of two different kinds of accidental scenarios due to "knock-on": i) propagation of low-severity initiating events (not considered relevant "top events" in the quantitative risk analysis of the plant); and ii) interaction of different "top events". A preliminary analysis of the first kind of knock-on accidents suggested that only radiation deriving from minor jet-fires or pool-fires is likely to cause these events. On the other hand, radiation, overpressure and missiles are likely to cause the second kind of events. However, the accidental scenarios deriving from the second kind of "knock-on" events may be analyzed superimposing the physical effects (radiation, overpressure, toxic gas concentration) separately calculated for the risk assessment of the interacting top events. Preliminary criteria for the estimation of the probability of both kinds of "knock-on" accidents were developed, based on the identification and quantitative assessment of the initiating causes of these events.

INTRODUCTION
The availability of quantitative procedures for the estimation of "knock-on" hazards is of particular importance for comprehensive industrial hazard assessment in areas where many different hazardous industrial activities are present. Directive 96/82/EC [1] requires the implementation of land use planning criteria in order to minimize the exposition of the population to industrial hazard. The proposed Italian legislation for the application of Directive 96/82/EC identifies areas where a "high concentration of industrial sites" is present and where the comprehensive analysis of industrial hazards is required. The development of land use planning criteria for the reduction of industrial hazards for the population calls for the application of quantitative area risk analysis (QARA) methods [2]. However, available QARA techniques are mainly derived from quantitative methodologies for the analysis of single risk sources. Thus the main limitation of the QARA techniques currently available is in the correct analysis of the effects of the interaction of the different risk sources present in a narrow area. In particular, specific quantitative criteria for the estimation of "domino" or knock-on accidental scenarios are still lacking, even if it is well known in the literature that also minor accidental events may start "knock-on" phenomena that may result in high-severity accidents [3].

Previous work in the field of "domino" accidents assessment was addressed to the identification of the threshold values of physical effects that may cause "knock-on" phenomena [4]. The available thresholds for damage propagation to process equipment were
used in the present analysis for the development of procedures for "knock-on" quantitative hazard assessment.
The aim of the present work was the development of preliminary criteria for the quantitative evaluation of knock-on accident hazards. The study was carried out within a more general research project concerning the revision and further development of QARA techniques and softwares for the application to industrial risk assessment of an Italian industrial area. Therefore, the procedures for the evaluation of knock-on effects were oriented towards the development of a systematic approach suitable to be combined with the use of vulnerability models for hazard assessment.

IDENTIFICATION OF ACCIDENTAL SCENARIOS CAUSED BY KNOCK-ON EFFECTS

Types of knock-on effects
The first problem that should be faced in the assessment of knock-on accidents is the identification of the accidental scenarios. Even if conventional techniques as event tree method may still be used, it seems useful to approach the problem introducing different categories of knock-on accidents.

As a matter of fact, knock-on accident may have two different causes:

i) propagation of low-severity initiating events; or

ii) interaction of different "top events"

These two categories of knock-on accidents may take place separately, but may also result in a single accident. An example is given by an accident that took place in an Italian plant for ethylene and propylene production in 1985. The accident was initiated by the rupture of a small diameter (2") ethylene pipe caused by the unbolting of a flange due to vibrations originated by repeated opening and closing of a safety valve. A minor jet fire started, that impinged on a 600mm pipe containing C2-C3 hydrocarbons. The pipe suddenly ruptured and a major jet fire started. The ignited jet impinged a vertical pressurized propane storage tank. In a few minutes, a first BLEVE took place, followed by the BLEVEs of several other pressurized storage vessels present in the tank park. The plant was almost completely destroyed.

This example shows both the possible knock-on effects. The main jet fire was started by a minor event as a 2" pipe jet fire. This event was possibly neglected in plant safety analysis, since a jet fire from a 2" pipe is not likely to be considered a "major accident" if only primary consequences are considered. On the other hand, the complete sudden rupture of a 600mm pipe is usually not considered in plant safety analysis, since primary external events causing the rupture of a pipe of diameter higher than 10" are regarded as highly unlikely. Thus if knock-on effects are overlooked, the consequence analysis of the jet-fire of the 600mm pipe could possibly be neglected.

Nevertheless, the more severe consequences of the accidents were caused not from the first major event (the 600mm pipe jet fire) but from the secondary major events: the BLEVEs of the pressurized tanks. These were the consequence of the second type of knock-on effects defined above. The safety analysis of pressurized storage vessels usually considers the possibility of tank BLEVE and includes BLEVE consequence analysis. However, the frequency of this top event is usually estimated only on the basis of sequences of primary events, as the release and ignition of flammable material from the tank. The increased hazard caused by possible knock-on effects is in general neglected, also due to the lack of well-accepted procedures for quantitative knock-on assessment.
The example given above shows that the accidental scenarios due to the two different types of effects have quite distinct features. Thus the methods to be used for the identification of the accidental scenarios are quite different.

Identification of accidental scenarios caused by the first type of knock-on effects

In order to define the scenarios due to the first kind of knock-on effects (propagation of low-severity initiating events), it is necessary to identify all potential low-severity initiating events (LSIE). Assuming that the hazard and operability analysis (Hazop) of the plant is available, the identification of LSIE may only require the critical revision of all the top-events identified in Hazop but considered of negligible importance and not further examined in consequence analysis. Minor jet fires (i.e. from small diameter pipes or valves) or pool fires (i.e. caused by leakages from seals) are the more likely events that may cause accident scale-up.

In order to assess the possibility of LSIE to cause propagation effects resulting in a major accident, criteria to evaluate the damages to process equipment due to radiation or pressure blast should be used. Thresholds values given in the literature [3] are of 37 kW/m² for radiation and of 0.7 atm for overpressure.

The LSIE propagation analysis may result in:
1) The identification of accidental scenarios not previously considered in the safety analysis of the plant, thus requiring a complete frequency and consequence analysis
2) The identification of knock-on as a cause of accidental scenarios considered unlikely and thus neglected in the consequence analysis (i.e. the sudden and complete rupture of pipes of diameter higher than 2\textquotedbl{}). The assessment of these scenarios requires the revision of the frequency analysis and a complete consequence analysis of the event.
3) The identification of knock-on as a further cause of accidental scenarios already considered in the safety analysis of the plant. The assessment of these scenarios requires only the revision of the frequency analysis of the event.

Identification of accidental scenarios caused by the second type of knock-on effects

The identification of scenarios caused by the second type of knock-on (interaction of different "top events") requires the analysis of the effects of primary accidental scenarios that may start secondary events. These are radiation, overpressure and missiles. The possible scale-up should be considered on the basis of threshold values for accident propagation as those given above. However, no threshold criteria is available for missile projection, that should necessarily be assessed on the basis of probabilistic models.

Nevertheless, since the consequences of both the primary and secondary accidental events are estimated in the safety analysis of the plant, the assessment of knock-on accidental scenarios of this second type only requires a frequency analysis.

FREQUENCY ANALYSIS

Frequency analysis of accidental scenarios caused by the first type of knock-on effects

The frequency evaluation of this second type of knock-on effects may still be based on conventional techniques as fault and event trees. Frequency of the LSIE can be calculated by fault tree method. Quantified event tree methods may be used to evaluate the probability of accident scale-up, that is the more critical point to assess, since this value is dependent on uncertain factors as intervals between equipment inspections, pipe resistance to radiation, etc.

Frequency analysis of accidental scenarios caused by the second type of knock-on effects

Also due to the lack of quantitative procedures for knock-on assessment, in the conventional approach for the safety assessment of chemical plants it is a common practice to consider the different top events as "independent events". In frequency analysis, this means that usually the
The probability of an accidental scenario is considered independent (and thus not influenced) from the probabilities of the other possible scenarios. Thus the quantitative estimation of domino effect frequencies calls for a probabilistic approach for the quantitative evaluation of the possible interaction between different accidental scenarios. An empirical approach to the problem is reported in the literature [5]. However, the use of probit functions for the estimation of plant equipment damage probabilities due to radiation and pressure blast [4] seems more suitable for frequency evaluation.

**CONSEQUENCE ANALYSIS**

*Consequence analysis of accidental scenarios caused by the first type of knock-on effects*

With reference to the three different situations defined in section 3, consequence assessment of the event is already available in case 3. In cases 1 and 2, conventional methods should be applied, thus requiring the use of quantified event trees, release models and fire, dispersion or explosion models. Vulnerability models based on probit equations may be used to evaluate damage probabilities [4].

*Consequence analysis of accidental scenarios caused by the second type of knock-on effects*

These scenarios are the result of accidental events for which a full consequence assessment should be available. A first approach to the consequence analysis may be to neglect the synergetic effects that may arise from accident interaction. Thus accident consequences may be analyzed superimposing the physical effects (radiation, overpressure, toxic gas concentration) separately calculated for the single scenarios that take place.

An even more simple approach is obtained if vulnerability functions are used for damage evaluation. In this case, if the non-linear dependence of dose-effect relation in vulnerability equations may be neglected, damage probabilities of the single events can be directly added to yield at least a rough estimate of the overall damage probability. This result is of particular interest in QARA techniques, were the vulnerability maps of single accidental scenarios are usually available.

**CONCLUSIONS**

An approach for the assessment of knock-on effects in QARA was developed. Criteria for the quantitative evaluation of knock-on scenarios were obtained. The proposed approach shows that only in a limited number of cases a full consequence and frequency assessment is necessary for knock-on scenarios. In particular, if synergetic effects are neglected, knock on scenarios resulting from the interaction of different "top events" may be evaluated from probabilistic techniques using the maps of the physical effects (radiation, overpressure, toxic concentration) obtained for the single events.

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BIAS IN CATASTROPHIC FAILURE RATES

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ABSTRACT
In the Netherlands a Quantitative Risk Analysis (QRA) is obligatory for post-Seveso industry. For these QRA's the probability of a full loss of the contents of a pressurised vessel is of major interest. Not only because failure of vessels is often the dominating scenario in risk contours off-site, but also because this frequency acts as a central reference in obtaining failure rates for other containments.

Currently this reference frequency is 1E-6/y (once a million year per containment), which can lead to a figure for catastrophic failure as low as 5E-8/y. During the last years in the Netherlands this figure has indeed been applied for storage under special care of LPG, chlorine, ammonia, etcetera. These Dutch figures are no longer in line with those of other governmental bodies like the HSE (United Kingdom) and AMINAL (Flemish Belgium). Somewhere the process must have diverged while establishing a set of specific frequencies, because all three above mentioned countries used the same case material (Smith and Warwick, 1981, 1991).

These differences can be explained by the application of additional judgement. This subjective (or even subjectivistic) part in the derivation of a catastrophic failure rate apparently differs between countries. The main goal of this paper is to separate the figures into a part which is based on case frequencies, and a part which is based on additional beliefs. To some extent this situation is inevitable because of the occurrence of insufficient case material to obtain fully frequency-based failure rates. But the subjective approach also has a number of disadvantages.

Bias in catastrophic failure rates

INTRODUCTION
This paper describes and analyses in three paragraphs some routes used to get a failure frequency for catastrophic failures:
1. The available material is sufficient for determining a probability of about 1E-5 (per year, /y omitted in the rest of this paper), but without much distinction in types of vessels or sizes of failures;
2. To overcome this lack of detail, additional material has to be applied, which leads to a subjective probability. This leads to differences in failure rates between countries;
3. An example will be presented where the repeated application of subjective material leads to problems.

Finally a number of disadvantages is considered.
Frequencies for pressure vessels

It is very hard to get an average frequency for a catastrophic failure of pressurised vessels, simply because the occurrence of catastrophic failures is low, and therefore all kind of vessel types and failure modes are included in databases. In 1981 in the COVO study Technica (now DNV) ran into a lot of discussion whether or not a range of presented failures also covered catastrophic releases. In order to obtain an estimate for the catastrophic failure rate of pressure vessels this range has been divided by a factor of ten (COVO, p. 2-356), and the failure rate for storage vessels was set at 3E-6. This figure has survived quite long, it was for example still used in 1994 (Taylor p.160). By the time of the implementation of the first Seveso-directive (1988) the recommended figure for all vessels was already down to 1E-6 in the Netherlands (not explained in this paper).

Backtracking the figures for pressure vessels revealed that a lot of handbooks and references use the survey of Smith and Warwick (1981, 1991). In the update of 1991 they presented a failure rate of 7E-5 (at 95% confidence level, average 4E-5). The latest update on this figure seems to be the work by Davenport (1991) who, by checking with nine other surveys, brought down the 95%-estimate for catastrophic failure to 1.2E-5. Also some earlier conclusions were questioned, for example that a vessel is more likely to fail within the first few years of operational life. This paragraph illustrates some of the figures and references used by the HSE for QRA's in the United Kingdom.

Always a correction has been applied due to the definition of "catastrophic". For example in Belgium this word is used only for failures with a total loss of containment such that the contents are lost in a neglectable time. However, Smith et al recorded "disruptive events ... so severe as to necessitate major repair or replacement". Working on this problem for the Belgium "Failure rates"-handbook (AMINAL 1993) DNV corrected for this problem by redistributing 46 cases over different leak sizes, only the highest considered representative for catastrophic failure. The figure obtained for catastrophic failure of pressure vessels is 6.5E-6 (estimated 95% upper bound 2E-5). This figure applies to pressure vessels for storage only.

Thus, although some judgements concerning representative cases already creeps in, a catastrophic failure rate of about 1E-5 might be considered as an frequentistic validated estimate.

Examples of additional beliefs

The AMINAL approach also needs non-frequency elements. For example the Smith and Warwick records do not contain enough data for making a distinction between reactor vessels and those for storage. The COVO-study stated that the base failure rate for operating in a process environment is normally multiplied by a factor of 3-10. DNV checked this factor by engineering judgement in a Delphi process, and applied these results to obtain a catastrophic failure rate specific for reactors. This result is about 1.3E-5.

In the Netherlands such a factor has not been applied, hence pressurised vessels, atmospheric storage tanks, columns and reactors are all modelled alike. However, other factors are indeed applied to obtain a more detailed modelling for catastrophic failure. For example an instantaneous release of the contents of a vessel can result in a significant lower toxic exposure than when the release takes 10 minutes. The modelling of total release is therefore
split in two scenarios (instantaneous and in 10'), each with a frequency of 2.5E-7 (the other 5E-7 dealing with the connections). Because there are no other scenario’s leading to the loss of the total contents of storage tanks of similar, the catastrophic failure rate (as defined in the previous paragraph) can be 5E-7. In certain extra safe conditions, described in the next paragraph, an extra decrease by a factor of 10 is stated in the Dutch handbook (A73, 1994).

Also for the UK some examples of further differentiation in the frequency for pressure vessels are presented. The base rate is about 6E-6, partially based on confidential additional data (Hurst, 1992). In some cases, for example LPG storage, a lower figure of about 2E-6 might be representative (Crossthwaite 1988). On the other hand the HSE stated that in very demanding conditions like an ammonia plant, a 3 times higher figure might be appropriate.

Thus, this leads to the figures shown below.

<table>
<thead>
<tr>
<th>Catastrophic failure rate</th>
<th>Belgium</th>
<th>Netherlands</th>
<th>United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>High demand</td>
<td>13</td>
<td>0.5</td>
<td>18</td>
</tr>
<tr>
<td>Storage vessel</td>
<td>6.5</td>
<td>0.5</td>
<td>6</td>
</tr>
<tr>
<td>Minimum</td>
<td>*</td>
<td>0.05</td>
<td>2</td>
</tr>
</tbody>
</table>

* No figure recommended, indicated factors typical in the range 0.2-10x

**EXTENSION OF THE APPROACH**

In the late eighties there was a need for more differentiated failure rates in the Netherlands. Common sense told that a well-inspected first class pressure vessel for storage should have a lower figure than some rusty roof tank. A lot of the collected failures had known causes like operator error, internal and external corrosion, stress, mechanical impact, etcetera (see for a summary AMINAL p.22). Could a permit holder give reasonable proof that these causes were less likely than the average, then a 10-fold reduction in failure rates was granted. In a number of cases for pressure vessels under storage conditions this led to a frequency for catastrophic failure of 5E-8. This looks like another expert-based step, necessary by lack of data, but there are some major differences compared to the earlier examples.

In this case there is at least an overlap between this last step and conditions earlier in the process of obtaining the failure rate. The base failure rate has been taken from the COVO study. Conditions stated with the chosen 3E-6 are: static, vibration free, no external or internal corrosion, no thermal cycling, and operator error and equipment malfunction must be calculated separately (COVO, summarised from page 2-356). Therefore some of the conditions are used twice, and the total supposed reduction based on this extra safety is a factor of 100.

Another difference with other steps is the absolute level of the failure rate. If already at a level around 1E-5 failure-causes like operator error must be calculated separately, then the not-included causes become quite a list at 5E-8. Events like flooding, earthquake, impact by aeroplane etcetera, all in the 1E-7 range, should be analysed at such low frequencies.

Thus, the extension of a subjective approach is limited here in two ways. Both the line of reasoning and the isolation of causes ran into difficulties. This is not an unique example or a new conclusion. Even if long historical records have led us to assess the numerical values we are using probabilities in the degree-of-belief sense (Apostolakis 1990).
CONCLUSIONS

It has been shown that a purely frequency-based approach is insufficient to obtain detailed figures for catastrophic failure rates. The subjective additions have led to differences in recommended failure rates in various countries. Although not scientific sustainable, other and different kinds of bounded rationality may exist for a valid process of obtaining these low numbers, but clearly there is a limit to this approach.

The advantages of these additions are clear:

- failure rates for different types of pressurised vessels;
- factors for expressing differences in operational environment;
- the possibility of expressing extra precautions in the failure rates.

These figures are strong recommendations by national administrative authorities. They will be used for QRA's under the Seveso-directive in at least the mentioned countries. In such a process a number of disadvantages might emerge:

- the QRA of a plant or a transportation system can't be used in a different (even European!) country;
- a risk consultant or a contractor has to use local databases and has to adapt software;
- incompatibility with figures used for other purposes, like risk-based inspection, insurance, disaster planning, etcetera;
- difficulties in incorporating new knowledge and new safety-measures into adapted failure rates.

These disadvantages could at least be mitigated if an European organisation, for example CDCIR might keep records of the reasons and conditions sustaining these national figures.

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The author gratefully acknowledges the assistance by Pol Hoorelbeeke (DNV Antwerp) and Peter Buckley (HSE Bootle) in obtaining the reference material.
SYNERGETIC EFFECTS AND NATURAL RISK ANALYSIS

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ABSTRACT
Any natural hazard represents a sum of synergetic interdependent chain subprocesses, which could either intensify or make it less intense. In the natural conditions, the enforcement mechanism unaffected by human activities reveals itself, as a rule, within a very limited period at the initial stage of the process development, and the mechanism of weakening is shown within a more extended period of time at the next stages.

Technological effects usually very intensify the process and increase the duration of the period when separate natural processes amplify each others. Such effects take place when the material and energy come into a natural system or are removed from it.

Negative synergetic effects manifest themselves more distinctly and on a larger scale in the situation when the complex of interdependent natural processes of different genesis take place, for examples: earthquakes, landslides, collapses; any natural hazard and destruction of buildings, human losses, etc.

The modern procedure of natural risk analysis therefore includes first of all creation of the models, forecasting the development of such negative synergetic processes and their consequences in natural, technological, and social spheres.

SYNERGISM OF NATURAL HAZARDS.
Socially hazardous processes related to inorganic nature can be divided (with respect to the environment) into geological, hydrogeological, meteorological, and cosmic processes. The gravity fields of the Earth, Moon, Sun, and planets of the solar system, as well as solar radiation, tectonic, temperature, magnetic, and other fields caused by complex matter and energy transformations in the Earth’s interior, are the general factors (driving forces) of these processes. The above factors govern the effects external for the corresponding environments and specify the general time-space direction of development of all hazardous natural and technological processes (HNTP). The action of the environment, including the technosphere, belong to the external effects for a certain medium.

All these environments are in the state of mutual competition and as if try to expand at the expense of other environment. Such an interaction results in the development of certain destructive processes most intense in the boundary zones and transient (buffer) zones of matter formation at different levels of organization. The latter have protective functions regulating and damping the interactions of competitive environments in the feedback circuit.

The complex cosmogeological processes resulted in the formation of the asthenosphere, Earth’s crust, atmosphere, and hydrosphere are the successive acts of self-organization of the primary Earth’s matter, which govern the state of equilibrium between this matter and the outer space. From these theoretical positions, any HNTP is both a natural component and continuation of the above global process of matter self-organization, as well as organization of local processes originating as a result of disturbances in the state of equilibrium between different terrestrial environments and (or) their sections.
Fig. 1. Synergetic development models of the typical geological hazards.

The processes: A - deluvial and talus drifting; B - landsliding due to the coastal erosion; C - karstification; D - technogene rise in groundwater level; E - coastal abrasion. (+) and (-) signs indicate the relationship, which could result in the increase or decrease of the process activity.

According to the concepts of sinergism - the science of self-organization of different systems - any natural environment is open, irreversible, and dissipative. In other words, it is the system with a regular structure non-isolated from other environments, which was originated and exists due to matter and energy exchange with other environments. The above exchange proceeds as certain processes often hazardous for the society. The sinergism considers them as the manifestation of chaos related to energy dissipation and disorder. On the other hand, the same processes generate new stable subsystems or an order from chaos, because of which they are called dissipative processes. It is the set of interrelated successive processes resulting in the destruction or generation of any systems that governs the process of self-organization of the systems. Underflooding, loess collapse, seismic tremors, landslides, rockfalls, avalanches, leaching, and karst formations are typical examples of self-organization (Fig. 1). Similar
processes and environmental sections, where these processes do not destroy the structure of the systems, or, more exactly, result in their constant destruction and

Relations 1 and 2 reflect the sequence of appearance and the mutual intensification of adverse effects, respectively subsequent restoration, are called self-regulating. Such a self-regulation is usually accompanied by income of matter and energy expended for the neutralization of external actions and maintenance of the state of equilibrium. For example, abrasion and accumulation at coasts, resulting in the formation of relatively stable sections of erosion and displacement and accumulation of sediments are such self-regulating processes. A relative stability of sand dunes, long-term levels of ground and surface waters, anticyclonic regions, and other similar phenomena is maintained in such a manner.

The above complex chain processes of different genesis and related effects (phenomena) of self-regulation and self-organization of the systems of common origin and specific succession of development are called sinergetic processes. A mutual intensification of negative effects is a specific feature of sinergetic processes, which is most typical of the initial stages of their intense development until the formation of additional parasystems relatively resistant to external actions, i.e., until the full-scale action of the negative feedback mechanism (Fig. 1). Such an intensification of rare events (large landslides, earthquakes, etc.) lasts for seconds and minutes, and that of permanent processes induced by powerful external sources continues for several years. The complex of processes proceeded during the Caspian Sea level rise from 1978 to 1996 is the evidence for the permanent intensification. A certain time delay of sinergetic processes relative to an inducing factor (process) is their second specific feature. The third feature is an inertial development of a process after weakening or termination of the action of an inducing factor (Fig. 2).
SYNERGETIC MODEL OF RISK ANALYSIS.

The process of natural risk analysis can be illustrated as a synergetic schematic model. The ideal procedure of such an analysis includes (Fig. 3)

1. The forecasting of the type, place, time, intensity and exposure time of natural hazards in various parts of the territory in question;
2. The assessment of the vulnerability (probability of the relative losses) of the exposed objects for the disasters of a certain type, intensity and exposure time;
3. The assessment of the partial (related to separate hazards) and integral social, economic and ecological risks of losses caused by those hazards, taking into account their mutual enforcement of their possible negative synergetic effects;

Natural risk management through the reduction or elimination of the existing (possible) negative impacts, or through the reduction of vulnerability from certain hazards. The procedure presumes that each new cycle of the analysis starts after the adoption of management decision aimed at reducing possible losses. Therefore we apply a normal effective management concept that includes feedback. The analysis controls itself. It means that the intensity of the analysis fluctuates depending on results obtained at the end of each stage.

Almost any natural catastrophe is a result of synergetic interaction between several natural and, more and more often now, technological processes. Those processes jointly cause more damage than each by itself.

For example, the losses caused by most catastrophic earthquakes of the 20-th century could be considerably reduced if:
1. Epicentral zones of those earthquakes were not subject to, mostly uncontrolled, urbanization;
2. There was no ground water rise to critical points (3-4 m) due to pipe leakage that increased the seismic blow by 1-2 balls and led to the decrease in soil solidity and to the formation of quicksand’s, landslides, stonefalls and mud flows.

Therefore the reliability of the natural risk assessment and the efficiency of safety measures depend heavily on the extent to which all the above mentioned synergetic factors are properly accounted for in the forecasting model. These models should in near future replace the common models' like tree of events and faults.

Synergism is based on the idea that the systems of different genesis develop similarly (at attractors), i.e., tend to reach a stable state in a specific space. The advanced theories of
bifurcations, disasters, self-organized criticality, cellular automats, etc. are widely used and elaborated for the description of these systems. Adaptation and further development of the above theories, concepts, and ideas of sinergism as applied to natural systems and processes operating in them (with allowance for the historical imminence and nonlinearity of the latter) is one of the most prospective ways of improvement of the available methods for prediction, assessment, and control of HNTP risk and damage.

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MODELLING SAFETY MANAGEMENT AND SAFETY MEASURES FOR RISK ASSESSMENT AT AIRPORTS

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INTRODUCTION

In the aftermath of the El Al crash in the Bijlmer area of Amsterdam in 1992, decisions were made to carry out a risk analysis of the Schiphol airport operations. This resulted in the calculation of risk contours around the airport and the development of risk policy guidelines for land-use planning. Three zones with decreasing restrictions were set up, to guide decisions on demolishing existing houses and on stand-stills on new building of residential, industrial and other developments. This approach copies the existing land-use planning applied to major hazard sites in the Netherlands under the Seveso Directive, though it uses different risk levels for the various intervention decisions. Traditionally this approach has been used to decide on both the companies' proposals for expansions of site activities and on the local authority building plans. In addition to risk contours the airport also has noise contours defined for day-and night-time noise, which are also intended to be used in land-use planning.

Compared to airports, chemical companies are, however, relatively static activities. In the five years 1992-1997 the traffic at Schiphol increased by over 65%. In 1998 the planned growth was 13%, of which only 2% could be accommodated within the noise contours and urgent cabinet decisions had to be made to allow deviation from agreed policy to permit continued growth. The argument for doing so was partly that the noise limitations were based too much on predicted rather than measured noise, and partly because many of the places where the permitted levels would be exceeded had no houses. The government committed itself in 1993 also to a policy that the risk level should not be above the baseline level of the first assessment, despite the increase in traffic. In other words the risk level per movement had to improve at least in line with that increase, or the model had to be refined to be able to take other improvements into account.

EXISTING RISK MODEL

All of this has made the issue of planning contours and their underlying models a highly controversial one. The initial risk model (Piers 1993) was based on a three-phase risk assessment, considering the probability of a crash, the crash location and the size of the crash effect. The crash probability is driven by historical accident data from airports selected as similar to Schiphol (major airports in developed countries), eliminating accidents which are not credible at Schiphol because of terrain or other differences. The number of aircraft movements and the mix of aircraft types and ages are major determinants of the probabilities calculated. The crash locations are also driven by the same accident data and the flight paths and landing strip use distribution of the airport. Crash effects are influenced by aircraft types, fuel load, etc.

The existing risk model has been criticised by almost all parties, including the NLR which developed it, as being too crude for it purpose. It looks purely backwards at historical data. It only contains a limited number of factors which can be influenced by the parties at the airport.
It does not reflect other influences such as air traffic management, more advanced landing aids, stricter controls on aircraft, etc., which are under the influence of those parties. Hence, it gives no clear incentive to good airport management. The model is also purely aimed at external safety. None of the following scenarios are included in it: an aircraft crashing within the airport perimeter; taxiing accidents (c.f. Tenerife); accidents at the pier; terminal fires (c.f. Düsseldorf); a bomb on board a plane at the airport, or in the terminal building; major accidents in related activities such as fuel handling or transport to or from the airport (e.g. a major rail accident in the station under the terminal).

For all of these reasons there have been calls for the last 6 years to develop a causal model to make risk decisions (e.g. Ale et al 1996). Despite these, little action has been taken, apart from attempts to refine the selection and analysis of historical data for the original risk model. This has led to predictions, based on that model (RIVM 1998), that the government’s policy targets cannot be achieved.

WHY DO WE NEED MODELS?

There are two main purposes for models. One is for the planning authorities, who need to decide when the limits to growth of the airport and/or the communities around it have been reached. When should the whole airport, or at least its excess traffic, be moved to a new site elsewhere in the Netherlands or onto an artificial island to be built off the North Sea coast? A second purpose of modelling is to optimise the risk planning and management of the airport activities, wherever they are. This is something which interests primarily the players at and around the airport. The two purposes overlap considerably, but not completely.

The first can ignore most of the extra internal accident scenarios listed in the previous section. For the regulators it is also not relevant that the model should go into much detail of the causes underlying the scenarios it considers, provided that the parties concerned agree with the assumptions in the model. It is the lack of that agreement among the various parties which has fuelled the discontent with the current risk model. Arguably regulators prefer a model which is somewhat conservative. They are therefore less concerned with one based on historical data rather than causal predictions. Finally, with the Dutch quantitative risk standards, the model must be able to give an absolute risk contour, preferably with an indication of the range of error in it.

For decisions on design and operations it is vital that a model goes into much more depth, so that the factors under the control of the parties at the airport, or the ones they can indirectly influence, are represented in it. Examples of these are the exact flight paths and trajectories for approach and departure (e.g. curved departure routes to avoid overflying built-up areas, power-off descents), stricter post-maintenance checks, changes to ATC communications, improved bird management, etc. These need to be not only the technical and human factors elements of design and operations, but preferably also the management aspects such as training and competence assurance, incident analysis systems, disciplinary and incentive schemes for following procedures, maintenance or airport management certification, etc. Management audit is increasingly the preferred instrument for organisations to monitor their operations. A model must therefore link the factors to be reviewed in an audit with the most important process elements in risk control (Hale et al 1999a).

For management purposes a model needs to cover all the airport operations, and all the unwanted scenarios, whether those result in accidents or other undesired effects, such as noise, pollution or odour. The model does not have to be fully quantitative in absolute terms, but needs to be able to indicate priorities. This means it must be able to indicate which factors have a greater or lesser effect on risk levels. It needs to be sensitive to conflicting effects of
different measures (e.g. adverse safety effects of landing strip choice driven by noise considerations). It must also be able to indicate how proposed changes in the way activities are carried out at the airport can interact with each other. For example, if calculations show that approach path changes will benefit noise levels, the model must be able to say something about the consequences of such changes for instrumentation support, communications between pilot and ATC, and training support, all of which will have to be modified to control the risks of such changes.

MODELLING APPROACHES
The existing risk model is based on a very simple functional model of the airport process, which only considers the top event of the effects of planes crashing outside the airport perimeter. Both types of purpose discussed above can be satisfied by expanding such a functional model. Figure 1 shows a very basic expansion to cover more of the steps. It is important that the basic structure of the model be functional and not directly translated into the current operationalisation of each function, in order that it can cope with new means of fulfilling the function (e.g. fully automated landing instead of pilot landings, new instruments for windshear or local shower detection, etc.).

Figure 1: Functional overview of activities around an airport

The area inside the dotted line is the one considered by the current risk model. A functional model, such as this, can be expanded into more detail for each step, and can be linked to fault trees leading to the various top event scenarios which can occur within each step. Since the processes depicted in the model are highly dynamic, it matters greatly where in each step the failures or deviations leading to the scenarios take place. This means that a dynamic PRA model is preferable to model this. New system architectures are available to link the PRA to simulation models in order to achieve this (Koom & van Paassen 1998).

Such functional models can be built up in stages, by expanding the fault trees to show more levels of detail. Analysis of accident records can provide the first step in this process. Accident analyses enabled the PRIMA model for major hazard site to link a technical PRA to eight broad areas of management control (Hurst et al 1996). Beyond a certain level of detail, the modelling of the influences has to be based on theoretical modelling and expert judgement. The I-Risk project has taken that step for major hazard risk modelling, to link it to the modelling of management influences (Hale et al 1999a & b). The much greater level of detail provided in the standard reports on aircraft accidents and incidents provide a better
chance that this can support modelling to a more detailed degree for airport safety than for
major hazard risks.

The modelling developed for I-Risk linked technical and human error risk parameters to
safety-critical tasks in operations, maintenance, modifications and emergency situations. The
management of these critical tasks was then modelled in terms of generic management tasks
to delivery resources and criteria for them; availability of competent and committed people to
carries out the tasks; safe and well maintained hardware and well-designed interfaces; clear
safety goals with systems to resolve conflict with non-safety goals; good procedures and rules
and good planning to carry out the tasks. A similar approach offers a way of expanding the
risk models for airports also.

The more detailed the model, the more difficult it is to quantify it with any degree of
certainly, but the more valuable it is for operational and design decisions.

CONCLUSION
The development of models for risk assessment for such activities as airports will be a long
process. Quantified models for regulatory purposes can form the core, with relatively simple
functional modelling and conservative assessment of risk based on largely historical data. For
design and operational purposes this core needs to be built upon to produce qualitative and
semi-quantitative models in much greater detail, linking risk to operational factors under the
influence of parties to the system. With the use of expert judgement in both modelling and
assessment of priorities, such models can offer good support for predictive decisions,
particularly if they can be linked to dynamic simulation models to look at time-critical events
in the process.

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ABSTRACT
The Convention on Nuclear Safety (CNS) entered into force on 24 October 1996. The aim of the CNS is "to legally commit participating States operating land-based nuclear power plants to maintain a high level of safety by setting international benchmarks to which States would subscribe". The first CNS review meeting took place in April 1999, at which national reports were reviewed to assess the safety of nuclear power plants (NPPs) in the host countries.

The CNS has 14 substantive articles, which include consideration of the nuclear legislative and regulatory framework, the regulatory body, financial & human resources, human factors, quality assurance, assessment & verification of safety, radiation protection, emergency preparedness, siting, design & construction, and operational safety. However, the CNS does not include risk concepts anywhere in its text. Thus, only 6 of the 22 CNS reports reviewed under the sponsorship of the Austrian government include risk information, although probabilistic safety assessments (PSAs) have been performed for many of the 219 plants located in these countries. This paper summarizes the risk results that were presented in the CNS reports, and discusses risk information should be included in future CNS reports.

INTRODUCTION
The Convention on Nuclear Safety (CNS) entered into force on 24 October 1996. The aim of the CNS is "to legally commit participating States operating land-based nuclear power plants to maintain a high level of safety by setting international benchmarks to which States would subscribe". The CNS was adopted in the wake of the Three Mile Island and Chernobyl accidents, in an era in which significant safety issues were identified in nuclear power plants (NPPs) designed in the former Soviet Union (IAEA 1992a; IAEA 1996a; IAEA 1996b; IAEA 1996c).

The CNS has fourteen substantive articles, which include consideration of the nuclear legislative and regulatory framework, the regulatory body, human factors, quality assurance, assessment & verification of safety, siting, design & construction, and operation. Notwithstanding the breadth of these issues, the CNS does not include the word "risk" anywhere in its text. The CNS commits Contracting Parties to prepare National Reports, which are discussed at a triennial "Review Meeting", the first of which was held in Vienna in April 1999. In preparation for the Review Meeting, the government of Austria sponsored a review of 22 of the National Reports, covering 219 NPPs. PSA results were provided for only 23 of the 219 NPPs covered by the reports. Sixteen of the twenty-two National Reports did not include risk information, although probabilistic safety assessments (PSAs) have been performed or are in progress for most NPPs.

PSA PRACTICES IN THE NUCLEAR INDUSTRY
Licensing of NPPs was initially, and continues to be, primarily based on deterministic safety analysis reports (SARs), analyzing plant response to design basis accidents (DBAs). These
analyses are based on deterministic criteria, with the intent to ensure that, for all accidents within the plant design basis, there is defense-in-depth.

In 1975, the first NPP PSA was completed in the US (WASH-1400). During the next decade application of PSA methods increased in the nuclear industry. Following two beyond-design-basis accidents (so-called "severe accidents" at Three Mile Island Unit 2 in 1979 and Chernobyl Unit 4 in 1986) in operating NPPs, PSA methods were widely applied to identify weaknesses in design, maintenance, and operation of NPPs. There is now a consensus, backed up by methodology guidance documents (IAEA 1992b; INSAG 1992b; NRC 1983), that PSAs using best estimate values should be performed on all NPPs. Most countries also believe that the scope of the PSAs should include external man-made and natural phenomena hazards, and should consider accidents occurring at shutdown as well as at power (INSC 1998). PSA is considered to be complimentary to deterministic safety analysis (INSAG 1992a), and is used in periodic safety reviews in a number of countries (OECD 1992).

RISK RESULTS PRESENTED IN CNS REPORTS

Table 1 presents the risk results presented in the CNS National Reports. The Level 1 (core damage frequency) and Level 2 (large release frequency) results should be viewed in the light of the INSAG safety targets for existing NPPs. These safety targets are: (a) a core damage frequency (CDF) of less than $10^{-4}$ per year, and (b) a large release frequency (LRF) of less than $10^{-5}$ per year (INSAG 1992a).

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<th>Country</th>
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<th>LRF (before safety improvements)</th>
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<tr>
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<td>Vandellós II</td>
<td>---</td>
<td>$6.38 \times 10^{-7}$</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

PERSPECTIVES ON THE CNS AND NPP RISKS

The Convention on Nuclear Safety is notable for a number of reasons, but for the purposes of this paper there are two key points. First, neither the term "safety" nor the phrase "nuclear safety" is defined in the text of the Convention. Second, none of the following words and phrases typically associated with accidents beyond the design basis appear in the text of the
CNS: "beyond design basis accident", "risk", "frequency", "probability", "severe accidents", "core melt", "confinement", "containment", "containment failure", and "containment bypass".

The lack of a definition for "safety" and "nuclear safety", and the lack of mention of terms related to risk and severe accidents in the Convention on Nuclear Safety poses some very practical problems for the Contracting Parties. Only a small percentage of National Reports included risk assessment results, despite the fact that nearly all NPPs in the world either have been analyzed by PSAs or are in the process of being analyzed. It is beyond dispute that PSAs are widely used to identify gaps in defense-in-depth; indeed, a recent OECD report identifies hundreds of plant and procedure modifications in NPPs around the world which were based on PSA results (OECD 1997). Indeed, the importance of PSA is seen in the fact that most of the National Reports reviewed mentioned that PSAs had been or were being performed, even if PSA results were not reported.

RECOMMENDATIONS FOR RISK CONTENT OF FUTURE CNS REPORTS

We believe that it is important for the CNS Contracting Parties to take the next logical step and provide risk information in the second round of National Reports, which are scheduled to be prepared in 2001. Considering the level of detail provided in the 1998 CNS National Reports, and the potential usefulness of risk information, we recommend that the following information be provided:

- The plant name and date of PSA report, and whether the PSA will be updated periodically or maintained as a "living PSA".
- The identity of performing and reviewing institutions (including whether IAEA has performed an IPERS mission related to the PSA).
- A discussion of the PSA scope (for example, whether the PSA included external events and, if so, which ones; whether the PSA included accidents at shutdown; and whether the PSA included Level 2 results).
- A brief description of the PSA methods (for example, the methods used in human reliability modeling, seismic hazard analysis, fire hazard analysis, accident progression analysis, etc.).
- A summary of the PSA results, such as core damage frequency (CDF), large release frequency (LRF), dominant accident sequences, dominant initiating events contributing to CDF and LRF, and containment bypass accidents.
- A discussion of containment or confinement performance in severe accidents.
- A discussion of whether design and/or procedural changes were made (or are pending) as a result of the PSA, and how these changes influenced the results.
- A discussion of how the PSA results are expected to be impacted by ongoing or planned safety improvement programs.
- A discussion of how the PSA is being used or will be used by the utility and the regulator.

It may be convenient for the Contracting Parties to including this information as an appendix to their report, with appropriate reference provided in the main report in connection with Article 14, Safety Assessment and Verification. In addition, we recommend that the CNS be amended to include explicit reference to risk-related issues. It seems to us to be inconsistent, at the threshold of the 21st century, to be discussing nuclear safety without reference to PSA.
ACKNOWLEDGEMENTS
The CNS National Report review project was commissioned jointly by the Austrian Federal Chancellery, the Austrian Federal Ministry for Foreign Affairs, and the Austrian Federal Ministry for the Environment, Youth and Family Affairs. Our colleagues within the project provided information and insights that were useful in the preparation of this paper. However, the authors of this paper are solely responsible for the content of the paper.

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RISK FACTORS FOR POST TRAUMATIC STRESS SYMPTOMS 9 YEARS AFTER THE 1992 FLOOD IN THE VAUCLUSE (FRANCE)

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TRACK 1

SESSION 6

WATER RISK (1)
RISK FACTORS FOR POST TRAUMATIC STRESS SYMPTOMS 5 YEARS AFTER THE 1992 FLOOD IN THE VAUCLUSE (FRANCE)

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Replaced to Track 5; Session 6, page 871
A SURVEY OF RISK ASSESSMENT TOOLS FOR USE IN FLOOD DEFENCE PROJECT APPRAISAL - RECENT DEVELOPMENTS AND PRACTICAL APPLICATION

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ABSTRACT
Flood and coastal defence systems are vulnerable to the uncertainties in weather and climate, as well as less obvious risks due to the uncertain performance of schemes and delays in the planning or construction stages. Risk assessment and management is needed so that investment appraisal can take account of risks and uncertainties as decisions are made, and so that risks are identified and, where necessary, reduced as flood defence strategies and schemes are implemented. The paper outlines the basis of guidance currently being produced to encourage wider and more consistent assessment and management of risk in project appraisal for flood and coastal defence.

INTRODUCTION
A survey of flooding in Britain over the last 200 years found about 850 recorded flood events. About half of these were minor, but newsworthy, events whilst one every 10 years on average was classified as a 'Major' event, causing considerable damage to a region's cities, towns and villages, with perhaps tens of deaths and serious disruption and financial hardship to thousands of people. While modern flood defences and systems for flood detection, warning and response have reduced the likelihood of flooding and the risk of fatalities, flooding continues to cause major disruption and damage. For example, East Coast flooding in January 1995, flooding on the South Coast from gales associated with Hurricane Lili in 1996, and flooding caused by torrential rain in August 1997. Severe flooding affected large areas of central and eastern England in Easter 1998 and was, in many places, the most severe ever recorded. Autumn 1998 saw more records broken as rivers in the West of England and Wales rose to new record highs.

If there were no form of defence, the Ministry of Agriculture, Fisheries and Food (MAFF) estimates that the annual average damage from flooding and coastal erosion in England and Wales would be of the order of £2billion in national economic terms. Annually the government invests approximately £350m in construction, operation and maintenance of coastal and flood defences. This maintains risk at a reduced level but does not eliminate damage from flooding or coastal erosion altogether.

FLOOD DEFENCE PROVISION IN ENGLAND AND WALES
Flood defence policy, as set the Ministry of Agriculture, Fisheries and Food (MAFF), is aimed at reducing the risks to people and the developed and natural environment from flooding and coastal erosion by encouraging the provision of technically, environmentally and economically sound and sustainable defence measures. The Environment Agency, in partnership with local and central government and private organisations, implements the policy by building, maintaining and operating flood defence systems on main rivers and the coast, and providing advice to local planning authorities with respect to development control.
The overall policy aim is promoted, in practice, by a hierarchical system of planning, appraisal and decision-making (Fig. 1). Large scale plans such as Shoreline Management Plans (SMPs) or Catchment Management Plans set out the basic options for the flood and coastal defence taking account of existing developments, natural processes and possible interactions between different lengths of coast or river. Large scale plans form the basis of more detailed Strategy Studies, which incorporate short, medium and long term plans for implementation, together with economic (benefit/cost) appraisal of strategic options. Individual schemes are designed, constructed and maintained in line with the strategic plans for the coastline or catchment.

CURRENT PRACTICE

Current practice relating to risk have been identified and reviewed, in part at a Workshop held in February 1999 which was attended by 26 participants with experience of flood defence engineering, planning and management in the UK and The Netherlands. The main elements are:

- Loads on the system such as river flows, water levels, wave heights are assessed using well-established extreme value techniques, including analysis of correlation and joint probability of loads where appropriate\(^5\).
- Structural performance is usually assessed deterministically, although project appraisal can incorporate probability of structural failure and there are examples of use of structural reliability methods for assessment and design of coastal and river structures. More often, engineering 'rules of thumb' such as increasing embankment levels by a freeboard allowance, are used to allow for uncertainty.
- Sensitivity analysis is used to test the robustness of the economic case to uncertainties in key variables, although there is currently no firm guidance on which variables should be varied or by how much.
- In general the optimum defence level is based on the criteria of maximising the benefit/cost ratio. Where this corresponds to a standard of protection considered too low for the land use, consideration of the marginal costs and benefits is encouraged. MAFF publish indicative standards of protection for different land use classes.
- Operating authorities now use project risk management to identify and reduce risks in scheme procurement and construction\(^6\).

The current emphasis is on assessment at the scale of individual schemes, with insufficient attention to risk assessment and management in the large scale and strategic planning stages. These probably have the highest uncertainty in terms of what may happen in the future, and the greatest potential benefits from explicit consideration of risk in decision-making.
DEVELOPMENTS

There are now moves to improve the way risk is assessed and managed. As part of a review of guidance issued to operating authorities, MAFF are proposing to introduce a new series of Project Appraisal Guidance (PAG) documents. One of these deals specifically with risk assessment and risk management. This follows the finding that many risk-based tools are well developed but they are not being routinely or consistently applied to decision-making in flood and coastal defence.

The most important aspect of the new guidelines is the emphasis on integrated risk assessment and management to match the hierarchical planning, appraisal and implementation processes outlined in Section 2. This is necessary partly for pragmatic reasons, so that risk assessments at one stage can be transferred to the next, and partly to reflect the interaction of risk at different levels. Benefits will arise from the common use of similar techniques and concepts. For example, decisions at the SMP stage may be influenced by high level risks such as long term physical and social trends, but may also be influenced by detailed issues such as the technical feasibility of different options, or by the degree of confidence in modelling of physical processes.

The integrated approach means adopting appropriate methods at each stage (Table 1). This suggests a general increase in the use of analytical, quantitative, methods at the more detailed appraisal scheme appraisal stage, with more emphasis on qualitative methods and comparative risk assessments at the broader large scale planning stage. This reflects the principles of the model framework for risk assessment and management within the Environment Agency.

<table>
<thead>
<tr>
<th>All stages</th>
<th>Large scale plans</th>
<th>Strategy plans</th>
<th>Scheme appraisal</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Common definition of risk</td>
<td>- Hazard and impact identification</td>
<td>- Qualitative methods (eg multi-attribute techniques) for 'diverse' or intangible impacts</td>
<td>- Quantitative methods</td>
</tr>
<tr>
<td>- Use of risk register to record and manage risk assessment and management process</td>
<td>- Assess possible outcomes</td>
<td>- Probabilistic assessment of costs and benefits</td>
<td></td>
</tr>
<tr>
<td>- Appropriate / proportionate consideration of all risks relevant to the decision stage</td>
<td>- Scoring and weighting</td>
<td>- Analytical or expert elicitation of probabilities</td>
<td></td>
</tr>
<tr>
<td>- Recognition of uncertainty</td>
<td>- Multi-attribute techniques</td>
<td>- Probabilistic process modelling</td>
<td></td>
</tr>
<tr>
<td>- Recognition of physical (eg flood) risks, project risks and modelling / uncertain knowledge risks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Examples of approaches to risk assessment at different stages

The guidance is not intended to be prescriptive, but it will encourage wider and more consistent use of risk assessment and management. Here we select three examples.

- **Probabilistic analysis** will become more common as technology improves and Monte Carlo analysis becomes more accessible. We expect that probability of flooding will be used rather than implying risk levels from the 'design' water level, which will enable a wider range of schemes and strategies to be compared. For example, a scheme option which includes moveable gates which must be operated on receipt of a flood warning can be compared with another with the same nominal crest level but composed of fixed defence structures. Risk assessment can account for different risk and costs of different scheme types.

- **Probabilistic simulation** will be linked with models of processes such as beach evolution to study impact of decisions on long term behaviour, including impact of unusual weather conditions.
sequences. These approaches also shed light on the robustness of different strategies to uncertainty, and will accompany the move to 'soft' engineering based on flexible, adaptive, strategies.

- Acknowledging and communicating risk and uncertainty will influence the way information is presented to decision-makers and stakeholders. For large scale planning, in particular, there is likely to be a shift towards more realistic acceptance of the limits of knowledge, and the need to monitor and manage accordingly.

CONCLUSION
The new guidance will lead to improved decision-making in flood and coastal defence by taking proper account of risk, by recognising that 'things can go wrong', and by encouraging honesty and openness in dealing with the wide variety of risks and uncertainties faced by river and coastal engineers and managers. It places current good practice within an integrated framework which follows the overall flood and coastal defence planning process. A programme of research will be carried out over the next few years to develop new tools and techniques to improve understanding of uncertainty and to provide better information about risks to decision-makers.

ACKNOWLEDGEMENTS
The authors give acknowledgement to MAFF, who are responsible for developing guidance for flood and coastal defence project appraisal in England and Wales. We also thank Jim Hall of the University of Bristol for comments on this paper and all other participants at the Workshop 'PAG4 - Approaches to Risk Assessment' on 15th/16th February 1999 for constructive ideas.

BIBLIOGRAPHY
UNCERTAINTY ANALYSIS OF WATER LEVELS ON LAKE IJssel IN THE NETHERLANDS: A DECISION-MAKING ANALYSIS

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ABSTRACT

In this paper, the reliability-based optimal design of the dikes along the Dutch Lake IJssel (1500 km²) is studied.

INTRODUCTION

Lake IJssel is situated in the northern part of the Netherlands (Fig. 1). It has an area of approximately 1500 km². The lake is surrounded by dikes in order to protect the low-lying polders from flooding. The required safety against inundation of the polders is 1/4000 yr⁻¹. In Westphal et.al. (1997), a physical model has been developed for the water levels of Lake IJssel. It is based on WAQUA (a two-dimensional water flow model) and HISWA (a wave model). The model of Westphal has been analyzed in an uncertainty study by Vrijling et.al. (1999). Uncertainties with respect to water level, wind speed, wind surge, wave height, wave steepness, wave run-up, and lake oscillations were taken into account. Two locations along the Lake IJssel were considered in detail: Enkhuizen and Rotterdamsche Hoek (Fig.1). A short summary of the uncertainty analysis study of Vrijling et.al. (1999) will be given in the next section. The goal of this paper is to analyze the influences of the uncertainties in the water levels on the reliability-based optimal design of the dikes at the locations of Enkhuizen and Rott.Hoek. This will be subject in the main part of this paper. The paper will end with conclusions and the list of references.
UNCERTAINTY ANALYSIS OF THE PHYSICAL MODEL

The probability of $Z < 0$ (overtopping of the Lake IJssel dikes) was calculated by a first order reliability method (FORM) in Vrijling et al. (1999). Given the uncertainties in water level, wind speed, wind surge, wave height, wave steepness, wave run-up, and lake oscillations, the uncertainties in the probability of overtopping at the two locations were determined.

The results of the uncertainty calculations are summarized graphically in Figs. 2 and 3 for Rotterdamsche Hoek and Enkhuizen respectively. Notice the differences between the required crest heights for the three cases: intrinsic uncertainty, intrinsic + statistical uncertainty, and intrinsic + statistical + model uncertainty. These differences can be up to 1 metre. There has also been made a distinction between additive and multiplicative uncertainty modelling (Vrijling et al., 1999), but this distinction is not important for the next part of this paper.

Figure 2: Crest height as a function of the probability of overtopping for Rotterdamsche Hoek.

Figure 3: Crest height as a function of the probability of overtopping for Enkhuizen.

Notice that the probabilities of overtopping are given by straight lines in the above semi-logarithmic figures. This means that they can be described by exponential distribution functions: $P(K<k) = 1 - \exp(-(k-A)/B)$.

When the following notation is adopted:

- $P$ = probability of overtopping [1/yr]
- i.u. = intrinsic uncertainty
- s.u. = statistical uncertainty
- add. = additive model
- mult. = multiplicative model
- m.u. = model uncertainty
- $h$ = required crest height

the following table can be derived:
Table 1. Comparison of the distribution parameters and the required crest heights.

<table>
<thead>
<tr>
<th>Location</th>
<th>A (m)</th>
<th>ΔA (m)</th>
<th>B (m)</th>
<th>ΔB (m)</th>
<th>h for P = 1/4000 [1/yr] (m)</th>
<th>Δh (m)</th>
<th>P [1/yr] for h = 3.95 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotterdamse Hoek</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.u.</td>
<td>2.303</td>
<td>0.018</td>
<td>0.198</td>
<td>0.042</td>
<td>NAP + 3.95</td>
<td></td>
<td>1/4000</td>
</tr>
<tr>
<td>i.u. + s.u. (add)</td>
<td>2.285</td>
<td>-0.018</td>
<td>0.240</td>
<td>0.072</td>
<td>NAP + 4.28</td>
<td>0.33</td>
<td>1/1000</td>
</tr>
<tr>
<td>i.u. + s.u. (mul)</td>
<td>2.113</td>
<td>0.054</td>
<td>0.267</td>
<td>0.033</td>
<td>NAP + 4.33</td>
<td>0.38</td>
<td>1/1000</td>
</tr>
<tr>
<td>i.u. + s.u. (add)</td>
<td>2.492</td>
<td>0.089</td>
<td>0.2645</td>
<td>0.0665</td>
<td>NAP + 4.71</td>
<td>0.76</td>
<td>1/250</td>
</tr>
<tr>
<td>i.u. + s.u. (mul)</td>
<td>2.337</td>
<td>0.054</td>
<td>0.2832</td>
<td>0.0852</td>
<td>NAP + 4.70</td>
<td>0.75</td>
<td>1/275</td>
</tr>
<tr>
<td>Enkhuizen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.u.</td>
<td>1.559</td>
<td>0.041</td>
<td>0.183</td>
<td>0.017</td>
<td>NAP + 2.95</td>
<td></td>
<td>1/4000</td>
</tr>
<tr>
<td>i.u. + s.u. (add)</td>
<td>1.701</td>
<td>0.142</td>
<td>0.194</td>
<td>0.028</td>
<td>NAP + 3.33</td>
<td>0.38</td>
<td>1/625</td>
</tr>
<tr>
<td>i.u. + s.u. (mul)</td>
<td>1.600</td>
<td>0.041</td>
<td>0.183</td>
<td>0.017</td>
<td>NAP + 3.13</td>
<td>0.18</td>
<td>1/1600</td>
</tr>
<tr>
<td>i.u. + s.u. (add)</td>
<td>1.782</td>
<td>0.223</td>
<td>0.252</td>
<td>0.086</td>
<td>NAP + 3.89</td>
<td>0.94</td>
<td>1/100</td>
</tr>
<tr>
<td>i.u. + s.u. (mul)</td>
<td>1.700</td>
<td>0.141</td>
<td>0.273</td>
<td>0.107</td>
<td>NAP + 3.68</td>
<td>0.73</td>
<td>1/200</td>
</tr>
</tbody>
</table>

The results of this table will serve as input for the analysis of the economic optimal dike height in the next section.

RELIABILITY-BASED OPTIMAL DESIGN

In the reliability-based design of hydraulic structures, the idea is to determine the total costs function (Van Gelder et.al., 1997). By assuming the exponential distribution (with parameters A and B) for the probabilities of overtopping, we can write:

\[ C_{\text{total}} = I_o + I_k + \frac{S}{r} (1 - F(k)) = I_o + I_k + \frac{S}{r} e^{-\frac{k-A}{B}} \]

The optimal dike height follows from the minimization of the total costs function and can be expressed by the formula:

\[ k_{\text{opt}} = A - B \log \left( \frac{I_k Br}{S} \right) \]

and the optimal probability of failure is given by:

\[ P_{\text{opt}} = \frac{I_k Br}{S} \]
It is interesting to notice that the optimal probability of failure is independent of the $A$ parameter of the exponential distribution. The $\Delta A$ values from table 1 are therefore neglected in the determination of the optimal failure probability. An increase in the slope of the exponential distribution (i.e. $\Delta B > 0$), results in an increase in $p_{opt}$. From table 1, it was seen that more uncertainty results in a higher $\Delta B$-value. Consequently this leads to a higher optimal probability of failure.

The change in the optimal probability of failure (from $p_{opt}$ to $p_{opt}'$) caused by the increase in uncertainty (from $B$ to $B+\Delta B$) can also be expressed as follows:

$$p_{opt}' = \frac{B + \Delta B}{B} p_{opt}$$

Given an optimal probability of failure of $1/4000$ yr$^{-1}$ for Rott.Hoek, the inclusion of all uncertainties ($\Delta B = 0.0852$) leads to a new optimal probability of failure of $0.2645 = \frac{1}{0.198 \cdot 4000 / 3000}$ yr$^{-1}$. Instead of an economic optimal dike height of 4.70 m, a height of 4.60 m is the result. For the location of Enkhuizen, the proposed approach leads to a decrease in the dike height from 3.89 m to 3.77 m.

CONCLUSIONS
The reliability-based decision-making procedure which has been applied in this paper can successfully be used in the analysis of the optimal failure probabilities for the dikes along the Lake IJssel. The influence of the uncertainties lead to an increase in the probability of exceedance lines. When the hydraulic boundary conditions are modelled in an exponential way, analytical considerations can be given for the optimal probabilities of failure and the optimal dike heights.

ACKNOWLEDGEMENTS
The authors would like to acknowledge L. van Asperen, M. van de Paverd, R. Westphal, H. Berger, all from the Dutch Ministry of Public Works, Transport and Water Management for their contribution to this paper.

REFERENCES


THE USE OF L-KURTOSIS IN THE ESTIMATION OF EXTREME FLOODS

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ABSTRACT
In this paper, the use of the L-Kurtosis measure in the probability model selection for extreme river discharges is studied.

INTRODUCTION
Today flash floods are the number one weather-related killer in the United States, claiming an average of 150 lives each year, according to the National Weather Service. Flooding takes various forms: ice jams, when river ice breaks up in the spring and floes can get caught on bridges or other obstacles, damming the water upstream and causing it to overflow the banks (type A in Fig. 1), river flooding, as the result of days or weeks of continuous rain rivers can overflow their banks (type B), dam bursts as the result of extreme rainfall, design defects (type C), mudflow, when loose soil on a slope become so heavily saturated by intense precipitation that a spontaneous slide results (type D). The most dangerous type of flooding is a flash flood (type E), which usually occurs within minutes or hours of a tremendous rainfall. Flash floods can sweep away everyone and everything in their path. They are so strong they can toss boulders around like pebbles, rip out trees and knock down buildings and bridges. Water may reach heights of 10 metres or more, and the rains that cause them can also trigger dangerous mudslides.

Figure 1: Various types of floods (Swiss RE, 1999).

The probability of occurrence of extreme floods of each of the above given types can be modelled with PDF's (Probability Distribution Functions). The selection of a certain PDF is a difficult issue and depends on the criteria which are used to define the optimal selection. Many people have looked into this problem, of which are mentioned Yamaguchi (1997), Van Gelder et.al. (1997), and Burcharth et.al. (1994).

In this paper it is proposed to use the so-called L-kurtosis measure in the selection of a PDF to describe the occurrence probabilities of extreme floods. The paper is organized as follows. First a short overview is given of the theory of L-Moments and in particular the L-kurtosis. Then the results of some simulation experiments will be briefly presented. Finally a short case study will be described to find the optimal PDF for the river Meuse.

L-MOMENTS AND L-KURTOSIS
L-moments are summary statistics for probability distributions and data samples. They are analogous to ordinary moments -- they provide measures of location, dispersion, skewness,
kurtosis, and other aspects of the shape of probability distributions or data samples — but are computed from linear combinations of the ordered data values (hence the prefix L). Hosking and Wallis (1997) give an excellent overview on the whole theory of L-Moments.

Kurtosis is based on the size of a distribution’s tails. Distributions with relatively large tails are called "leptokurtic"; those with small tails are called "platykurtic." A distribution with the same kurtosis as the normal distribution is called "mesokurtic." The following formula can be used to calculate kurtosis:

$$kurtosis = \frac{E[X^4] - 3}{\sigma^4}$$

where \( \sigma \) is the standard deviation. The kurtosis of a normal distribution is 0.

The following two distributions have the same variance, approximately the same skew, but differ markedly in kurtosis.

**Figure 2: Examples of different kurtosis values.**

Note that in the above formula to calculate the kurtosis the observations are powered to the order 4. Small deviations in the observations cause a large error in the kurtosis. However, this is not the case if the L-kurtosis is considered. The L-kurtosis is calculated with formulae of the type:

$$b_r = n^{-1} \sum_{j=1}^{n} \frac{(j-1)(j-2)\cdots(j-r)}{(n-1)(n-2)\cdots(n-r)} X_j$$

in which \( X_j \) are the ordered observations and only linear combinations are considered.

**SIMULATION EXPERIMENTS**

In Pandey et al. (1999), various Monte Carlo simulations have been performed. They considered samples drawn from a known distribution (e.g., kappa distribution), and a set of several candidate distributions were fitted to the data based on matching L-moments. The PDF closest to the parent can be identified by computing divergence or probabilistic distance of each of the candidate distributions from the parent. Obviously, the distribution with the least divergence would be closest to the parent PDF. With this line of thinking, the experiments were designed to evaluate systematically the effectiveness of the L-Kurtosis criterion (the minimum difference of L-kurtosis of fitted PDFs from that of the sample) against the divergence criterion for estimating extreme quantiles. Results of the simulation experiments indicated that quantile estimates obtained from the L-kurtosis criterion are in fairly close agreement with those obtained from the minimum divergence criterion. In this respect, it can be concluded that L-kurtosis is a reliable indicator of distribution shape and its use in quantile estimation is very effective. Remarkable simplicity of computation makes the L-Kurtosis criterion an attractive tool for distribution fitting.
CASE STUDY RIVER MEUSE

In this case study the frequency distribution of the river Meuse (experiencing extreme high water in the winters of 1993 and 1995) is investigated in detail. A data set is given of size 86 consisting of annual maxima of river discharges. The analysis results are as follows:

<table>
<thead>
<tr>
<th>L-Moments</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPA</td>
<td>0.100E+01</td>
<td>0.1950E+00</td>
<td>0.9681E-01</td>
<td>0.2819E-01</td>
</tr>
<tr>
<td>GEV</td>
<td>0.100E+01</td>
<td>0.1950E+00</td>
<td>0.9681E-01</td>
<td>0.1260E+00</td>
</tr>
<tr>
<td>PE3</td>
<td>0.100E+01</td>
<td>0.1950E+00</td>
<td>0.9681E-01</td>
<td>0.1254E+00</td>
</tr>
<tr>
<td>GNO</td>
<td>0.100E+01</td>
<td>0.1950E+00</td>
<td>0.9681E-01</td>
<td>0.1300E+00</td>
</tr>
<tr>
<td>GUM</td>
<td>0.100E+01</td>
<td>0.1950E+00</td>
<td>0.1699E+00</td>
<td>0.1504E+00</td>
</tr>
<tr>
<td>GLO</td>
<td>0.100E+01</td>
<td>0.1950E+00</td>
<td>0.9681E-01</td>
<td>0.1745E+00</td>
</tr>
</tbody>
</table>

For six distribution functions (Generalized Pareto, Generalized Extreme Value, Pearson type III, Generalized Log-Normal, Gumbel and Generalized Logistic), the following L-moments are obtained:

Note that the GLO (line 6) with L-Kurtosis of 0.1745 gives the best fit (in L-Kurtosis sense) to the sample data. The 1/1250 years quantile is given by 4200m³/s.

CONCLUSIONS

The occurrence frequency models of extreme floods has been a subject of discussion during the last decades and will probably still be in the new millenium. The purpose of this paper was to introduce a new PDF-selection criterion, based on the L-Kurtosis measure. This criterion has been evaluated with a large Monte Carlo simulation scheme in a previous paper (Pandey et.al., 1999) and was applied in this paper on the extreme river flows of the River Meuse.
ACKNOWLEDGEMENTS
The authors would like to acknowledge Mr H Chbab from the Dutch Ministry of Public Works, Transport and Water Management for providing the Meuse data.

REFERENCES


CONCLUSIONS

The forecasting frequency models of extreme floods has been a subject of controversy during the last decade, and will probably still be in the new millennium. The purpose of the paper was to introduce a new POF-estimation technique based on the L-Kastner summary. This technique has been compared with a large Monte Carlo simulation scheme in a previous paper (Fassbender et al., 1998) and has been applied in this paper on the extreme River flows of the Rhine basin.
TRACK 1

SESSION 7

WATER RISK (2)
This paper deals with the influence of risk perception in risk management in Public Health. It reveals the existence and the nature of several ways of decision-making in the special case of an accidental drinking water pollution and its potential impacts and consequences on Public Health.

The decision-makers taken into account, usually work under time pressure with a lot of missing data. These situations considered do not involve enough alarms to allow decision-makers to set off pre-determined plans; they are potential pollution with unknown impacts and consequences. Most of the time the decision-makers are at a loss and have no references on which they could base their reasoning which leads them to a crisis we want to avoid in future cases. The main conclusions show the importance not only of feedback but also of reasoning by analogies.

A first part gives briefly the theory on which this study is based. From cognitive science, psychology and management we have made a synthesis in order to better understand the process of the decision-making of a decision-maker dealing with hazards and their potential impacts on Public Health.

A second part presents the case-study done with French public decision-makers. It describes the sample of decision-makers considered and the questionnaire and then gives the conclusions. Several appendixes explain the main results based on econometrics.

This case-study is mostly a descriptive study and we are now checking if those results can also become prescriptive.
RISK COMMUNICATION OF DRINKING WATER QUALITY ISSUES - A MENTAL MODELS APPROACH: HOW CAN THE UK WATER INDUSTRY FILL THE GAPS IN KNOWLEDGE WHICH EXIST BETWEEN EXPERTS AND CUSTOMERS?

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Professor J Colbourne, Consultant, Thames Water, Walton AWTW, Hurst Road, Walton on Thames, Surrey, KT12 2EG

This research work uses a mental model approach (Bostrom et al. 1994) to elicit and characterise the differences in knowledge between experts in Thames Water and customers. The methodology used is an expert mental model of drinking water built using an influence-directed network. Qualitative studies were conducted using a specially designed drinking water quality interview protocol with two groups of customers (complainers and noncomplainers) following a change made to their water supply. Results from this qualitative work revealed significant gaps in knowledge between experts in the company and customers affected by the change. The gaps (e.g. misconceptions, beliefs and valuations) are clearly related to a failure by the company to communicate specific information to its customers, the influence of regional media reporting and the resultant impact upon customer contacts into the company over a 26 week period.

The findings of the qualitative study were used to develop a customer perception questionnaire for use in a large-scale quantitative survey conducted during 1998. Pilot study results from this quantitative survey provides evidence to support mental modelling as a potentially influential research tool for eliciting, characterising and measuring public perceptions about drinking water quality issues.

Quantifying key gaps and misconceptions in knowledge held by different social groups will provide Thames Water, and water industry regulators, with a tool for designing future risk communications with customers, and for public consultation over controversial issues, such as, fluoridation of water supplies.
SMALL ROUND STRUCTURED VIRUSES: MOLECULAR DETECTION IN SPORADIC OR EPIDEMIC GASTROENTERITIS AND IN VARIOUS WATER SAMPLES, IN SOUTH-WESTERN FRANCE.


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**Service d’Hygiène Hospitalière, Hôpital Pellegrin, Place Amélie Raba-Léon, 33076 Bordeaux Cedex France

Small Round Structured Viruses (SRSV) are a major cause of gastroenteritis in collectivities. Moreover, these viruses are able to survive in environmental waters. The routes of SRSV transmission are not yet well understood but infection by interhuman contact, or by contaminated water or food, have been assumed.

Thanks to sensitive molecular techniques (Reverse Transcription and Polymerase Chain Reaction -RT-PCR), we looked for SRSV in human stools and water samples in our region. We were able to investigate a hospital outbreak of gastroenteritis possibly related to contamination of drinking water by a SRSV.

INTRODUCTION

SRSV (or Norwalk-like viruses), linked to the Caliciviridae, cause sporadic or epidemic gastroenteritis in adults and children. Over 50% of infectious gastroenteritis outbreaks could be due to SRSV (1, 2, 3). The mode of contamination by these viruses is still imperfectly understood. Transmission by interhuman contact (4) seems to be predominant. Nevertheless, these viruses were detected in environmental water samples or in shellfishes able to concentrate viruses from water (5). Thus infection by SRSV-contaminated food, shellfishes, or water, have been reported (6, 7, 8).

The sanitary authorities need sensitive techniques to control inocuity of food and water according to viral pollution, and to decide hygienic measures or decontamination treatment. Molecular biology techniques (Reverse Transcription and Polymerase Chain Reaction (RT-PCR)) might improve this control, especially for viruses such as SRSV, which cannot be cultivated yet.

We collected some data about SRSV in our region, by RT-PCR in several human faecal samples and in drinking or bathing waters. This gave us the opportunity to study a recent hospital outbreak of gastroenteritis, which could be due to water contamination with SRSV.

MATERIALS AND METHODS

Samples

-Sporadic gastroenteritis: 39 stools from patients suffering sporadic gastroenteritis were obtained from Bordeaux hospital wards. They were sent to our laboratory in order to look for group A Rotavirus, Adenovirus, SRSV, from November 1998 to February 1999.

-Epidemic gastroenteritis: in January 1999, stools from six patients hospitalized in a re-education ward, were tested in order to explore an outbreak of gastroenteritis. These samples were tested for enteric bacterial pathogens, group A Rotaviruses, Adenoviruses, and SRSV. Because of SRSV-positive samples and doubts about the quality of drinking water expressed
by the staff, seven drinking water samples were collected in the ward, from a drinking fountain and six taps. On the latter samples, SRSV PCR was performed.

-Bathing water samples: 26 samples from five bathing areas were collected during summer 1998 in South-Western France, and tested for SRSV.

Virological techniques
- Generic RT-PCR in SRSV polymerase region:
  Viral RNA was extracted from 50 μl stool suspensions (10%) or from 50 μl water by Boom’s procedure (9) using GuSCN and silica particles. Briefly, reverse transcription was performed after annealing with the degenerate primer NVP110 (10) and with murine leukemia virus RT (Roche, Meylan, France). Ten μl of the RT mix were then added to a first PCR mix with primers G1, G2, SM31 (5). One μl of this product was then added to a second PCR mix containing the primer pair N1, E3 to realize the nested PCR (5). PCR products were visualized on 2.5% agarose gel electrophoresis. This PCR was confirmed by liquid phase hybridization with a 5'-labeled probe, NVP116 (10).

-Rotavirus and Adenovirus:
  Group A Rotaviruses and Adenoviruses (types 40 and 41) were looked for in the stools by a latex agglutination assay, used in routine in our laboratory (Diarlex, Sirep, Montrouge, France).

RESULTS
Table 1

Sporadic gastroenteritis: among 39 tested stools, we found four SRSV-positive samples (10%). This important proportion of sporadic gastroenteritis potentially linked to SRSV encouraged further investigations by studying additional cases.

Epidemic gastroenteritis cases: among the six symptomatic patients, three stools out of six were SRSV-positive by RT-PCR and negative for other enterical pathogens. Three water samples out of seven were SRSV-positive: the common drinking fountain and two tap waters. All SRSV nucleotidic sequences performed in a polymerase fragment (results not shown) were identical. Just after the outbreak, water samples from 20 places in the whole hospital building were tested, and only one sample, from the ward where the outbreak occured, was SRSV-positive.

<table>
<thead>
<tr>
<th>Human samples</th>
<th>Water samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SRSV-positive</strong></td>
<td></td>
</tr>
<tr>
<td>Sporadic cases:</td>
<td>Bathing areas:</td>
</tr>
<tr>
<td>4/39</td>
<td>2/26</td>
</tr>
<tr>
<td>Epidemic cases:</td>
<td>Drinking water:</td>
</tr>
<tr>
<td>3/6*</td>
<td>3/7**</td>
</tr>
</tbody>
</table>

*: negative for Rotavirus, Adenovirus, bacterial pathogens.
**: drinking fountain, two tap waters.

Table 1: Detection of SRSV by RT-PCR in faecal and water samples.
Bathing areas: two out of 26 samples were SRSV-positive by RT-PCR, once in a water sample considered of good bacteriological quality (less than 100 CFU total coliforms or faecal Streptococci for 100 ml water), once in a water sample of medium bacteriological quality (more than 100 CFU total coliforms or faecal Streptococci for 100 ml water).

DISCUSSION

SRSV are assumed to be the first aetiologic agent of non bacterial gastroenteritis outbreaks, but their implications in sporadic gastroenteritis is not yet well understood. Among the 39 stools from sporadic cases sent to our laboratory, four SRSV-positive samples (10%) were collected. We therefore believe the presence of SRSV should be systematically investigated in this context.

During a hospital gastroenteritis outbreak, half the six patients were SRSV-positive, together with three drinking water samples collected in the ward, with identical nucleotidic sequences. Though we cannot exclude taps soiling by ill patients (11), we have to consider that drinking water network was possibly contaminated with SRSV. In any case, virological results helped the hospital hygienic department in deciding hygienic measures (carefull handwashing, consumption of mineral bottled water, intensified ward cleaning), and the gastroenteritis outbreak ended.

Furthermore, our environmental study allowed us to detect SRSV twice in bathing areas. As previously published, there was not automatically a correlation between viral and bacterial contamination (12). Though viral concentration procedures need to become as simple and efficient as possible, our preliminary results suggest a method to control water or shellfishes virological quality. Touristic regions such as South-Western France, may also possess oysters harvesting areas, and should therefore be studied for enteric viral pathogens, besides bacterial surveillance.

Highly sensitive molecular biology procedures, have become rapid, such as RT-PCR with liquid phase hybridization, and might prove very helpfull to better understand how SRSV circulate from environmental areas (water, food) to patients. SRSV, as other enteric viral pathogens do (hepatitis A virus, Enteroviruses...), seem indeed to represent an important risk for public health.

REFERENCES


NITRATE IN DRINKING WATER AND RISK OF CHILDHOOD DIABETES MELLITUS IN THE NETHERLANDS


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In recent years, several studies - e.g. from Yorkshire, Colorado U.S.A. and Sweden - have been published which describe a relationship between nitrate exposure and childhood type 1 insulin-dependent diabetes mellitus (IDDM). The present ecological study sets out to describe a relation between incidence of IDDM and nitrate levels in drinking water in The Netherlands. 1081 cases of IDDM were diagnosed in the period 1993-1995 among the age group of 0-14 year old children. The postal code areas of the places of residence of these cases were known. Data on mean nitrate levels in drinking water in the period 1991-1995 were obtained from the Dutch National Institute of Public Health and Environmental Protection and 25 Dutch drinking water supply companies. In this way, mean nitrate levels in drinking water in 3932 postal code areas in the whole country of The Netherlands could be obtained. Two different exposure categories with different nitrate concentration ranges were used. One category was based on equal number of children exposed to different nitrate levels (three nitrate concentration ranges of 0.25-2.08 mg/l, 2.10-6.42 mg/l and 6.44-41.19 mg/l); the other was based on cut-off values of 10 and 25 mg/l (three nitrate concentration ranges of <10 mg/l, 10-25 mg/l and >25 mg/l). With regard to both exposure categories, standardized incidence ratios were determined for IDDM with respect to nitrate exposure levels, gender and age (using groups of 0-4, 5-9 and 10-14 year old children) and compared in univariate analysis using the chi-squared test for trend; a comparison of incidence rate ratios was performed by multivariate analysis in a Poisson regression model. An effect of increasing age of the children on incidence of IDDM was found, but no effect of gender and no effect of nitrate concentration in drinking water on incidence of IDDM was observed. It is concluded that nitrate in drinking water at current exposure levels is probably not a risk factor for childhood type 1 diabetes mellitus in The Netherlands.
PHENOL REMOVING FROM THE WATER DURING THE ELECTROCHEMICAL GENERATION OF ACTIVE CHLORINE.


Laboratory of Ecological Chemistry, Chemical Department of the Lomonosov Moscow State University, 119899, Moscow, Russia

The problem of phenol destruction in water environment is of great theoretical and applied interest. The experimental data obtained by now that during electrochemical cleaning of phenol-containing water the destruction of the aromatic nucleus practically does not occur without the chloride ions. Therefore, among all existing methods of phenol water cleaning the due attention should be given to the method of the deep phenol destruction during the electrochemical generation of active chlorine that is developed by our laboratory. The electrochemical generation of active chlorine consisting from the \( \text{Cl}_2, \text{HClO} \) and \( \text{ClO}^- \) mix is carried out for the account of the electrolysis of phenol water solutions containing chloride ions.

We have obtained the rich experimental material with the use of a complex of electrochemical methods in a combination with other physical and chemical methods (titrimetry, gas-liquid chromatography, chromato-mass-spectrometry) that seems to be of the great theoretical and applied interest. Some of the obtained data are shown in the tables below.

### Table № 1.

Conversion of a modeling phenol solution during the electrochemical generation of active chlorine \( (C_R = 100 \text{ mg/l, } C_{\text{NaCl}} = 10 \text{ g/l, } i = 4 \cdot 10^{-2} \text{ A/cm}^2, \text{t_electrolysis} = 30 \text{ min}) \)

<table>
<thead>
<tr>
<th>Anode type</th>
<th>Phenol conversion, %</th>
<th>Anode stability at the prolonged loads (100h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( 0,1 \text{ N H}_2\text{SO}_4 )</td>
<td>( \text{H}_2\text{O} )</td>
</tr>
<tr>
<td>Platinized platinum (Pt/Pt)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Platinized graphite (Pt/C)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pure graphite (C)</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Data shown in the table № 1 indicate a high activity of tested anodes, especially in the acid and neutral environment. These data also indicate the highest stability of Pt/Pt to the prolonged anode loads.

According to the obtained experimental data the destruction of the aromatic nucleus during phenol conversion in conditions of the electrochemical generation of active chlorine takes place by the following scheme: phenol \( \rightarrow \) phenol chlorides \( \rightarrow \) dichlorophenols \( \rightarrow \) 2,4,6-trichlorophenols \( \rightarrow \) products of aromatic nucleus splitting.

The analysis of products of direct chemical phenol chlorination and electrochemical phenol chlorination (see table № 2) shows that in both cases the structures of these products are
identical. However the ratio of these products indicates a preference for electrochemical
effects.

Table № 2.
Composition of the products of chemical (I) and electrochemical (II) phenol chlorination in the
water according to the data of gas-liquid chromatography \( C_R = 100 \text{ mg/l, treatment time} = 30 \text{ min} \)

<table>
<thead>
<tr>
<th>Compound</th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenol</td>
<td>0.47</td>
<td>0.28</td>
</tr>
<tr>
<td>Orthochlorophenol</td>
<td>0.76</td>
<td>3.68</td>
</tr>
<tr>
<td>Parachlorophenol</td>
<td>14.91</td>
<td>8.59</td>
</tr>
<tr>
<td>Dichlorophenol</td>
<td>37.74</td>
<td>16.23</td>
</tr>
<tr>
<td>2,4,6-trichlorophenol</td>
<td>14.25</td>
<td>25.66</td>
</tr>
<tr>
<td>Total sum of phenols</td>
<td>68.11</td>
<td>54.43</td>
</tr>
</tbody>
</table>

These data show that the total content of phenol compounds in the products of
electrochemical chlorination is lower than in the case of chemical chlorination realized by the
using of chloric water. Moreover, the chlorine concentration in the chloric water during
chemical chlorination was twice as large as that in the case of electrochemical chlorination. In
addition during the chemical chlorination the prevailing products are dichlorophenols,
whereas in the case of the electrochemical chlorination the prevailing product is
trichlorophenol. All these facts indicate that electrochemical effects facilitate the replacement
of hydrogen with chlorine in the aromatic nucleus and the further destruction of the aromatic
system.

The high efficiency of phenol conversion during electrochemical generation of active chlorine
indicated in the case of modeling solutions was examined for the natural phenol-containing
sewage from a number of factories (pharmaceutical, petrochemical, household chemistry).
Results obtained for the sewage of petrochemical factory are shown in table № 3.

Table № 3.
The change in the composition of sewage from petrochemical factory after using the
electrochemical effects during 90 min.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration, mg/l</th>
<th></th>
<th>Conversion, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before the effect</td>
<td>After the effect</td>
<td></td>
</tr>
<tr>
<td>Phenol</td>
<td>245</td>
<td>4.3</td>
<td>98</td>
</tr>
<tr>
<td>Orthocresol</td>
<td>56</td>
<td>0.8</td>
<td>99</td>
</tr>
<tr>
<td>Metacresol</td>
<td>92</td>
<td>2.1</td>
<td>96</td>
</tr>
<tr>
<td>2,3-dimethylphenol</td>
<td>24</td>
<td>1.1</td>
<td>95</td>
</tr>
<tr>
<td>3,4-dimethylphenol</td>
<td>10</td>
<td>0.07</td>
<td>93</td>
</tr>
<tr>
<td>Ammonia</td>
<td>73</td>
<td>2.5</td>
<td>97</td>
</tr>
<tr>
<td>Cyanides</td>
<td>0.42</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Rhodanides</td>
<td>0.52</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

The comparison with the data obtained from the modeling solutions (see table № 1) shows that
the phenol conversion in natural sewage proceeds more slowly than in modeling solutions.
Such speed reduction is caused by the additional costs of the electricity for the oxidation of
organic and inorganic components contained in the sewage. At the same time, as it is seen from the table № 3, a high percentage of conversion is extended not only to phenol, but also to all other chemical components of sewage, that indicates a high efficiency of the cleaning. Despite of the high efficiency of phenol destruction during the electrochemical generation of active chlorine, a problem of the risk evaluation of possible dioxin structures generation during chlorination has not been solved yet. In this connection, as judged from the analysis of the literature, we are the first who realized an attempt of the quantitative chemical analysis of polychlorinated dibenzo-p-dioxins and dibenzofurans in a sample of a modeling water solution of phenol oxidized during the electrochemical generation of active chlorine. The analysis was performed in the Laboratory of Analytical Ecotoxicology in the Institute of Ecology and Evolution Problems with the use of chromato-mass-spectrometry. Some of obtained results are shown in table № 4.

Table № 4.

Results of the quantitative chemical analysis of polychlorinated dibenzo-p-dioxins (x ≈ ChDD) and dibenzofurans (x ≈ ChDF) in a sample of phenol solution, processed by an "active" chlorine.

<table>
<thead>
<tr>
<th>Determined component</th>
<th>Dioxin equivalent, DE</th>
<th>Results of the analysis</th>
<th>Concentration, pg/l</th>
<th>Concentration in DE, pg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,3,7,8-TChDD</td>
<td>1</td>
<td>18.16</td>
<td>18.16</td>
<td></td>
</tr>
<tr>
<td>1,2,3,7,8-PChDD</td>
<td>0.5</td>
<td>&lt; 0.2</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>1,2,3,4,7,8-PChDD</td>
<td>0.1</td>
<td>&lt; 0.2</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>1,2,3,6,7,8-PChDD</td>
<td>0.1</td>
<td>0.82</td>
<td>0.082</td>
<td></td>
</tr>
<tr>
<td>1,2,3,7,8,9-HxChDD</td>
<td>0.1</td>
<td>&lt; 0.2</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>1,2,3,4,6,7,8-HpChDD</td>
<td>0.01</td>
<td>4.87</td>
<td>0.0487</td>
<td></td>
</tr>
<tr>
<td>OChDD</td>
<td>0.001</td>
<td>15.43</td>
<td>0.01543</td>
<td></td>
</tr>
<tr>
<td>2,3,7,8-TChDF</td>
<td>0.1</td>
<td>&lt; 0.5</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>1,2,3,7,8-PChDF</td>
<td>0.05</td>
<td>428.44</td>
<td>21.422</td>
<td></td>
</tr>
<tr>
<td>2,3,4,7,8-PChDF</td>
<td>0.5</td>
<td>6.33</td>
<td>3.165</td>
<td></td>
</tr>
<tr>
<td>1,2,3,4,7,8-HxChDF</td>
<td>0.1</td>
<td>&lt; 0.5</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>1,2,3,6,7,8-HxChDF</td>
<td>0.1</td>
<td>&lt; 0.5</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>2,3,4,6,7,8-HxChDF</td>
<td>0.1</td>
<td>&lt; 0.5</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>1,2,3,7,8,9-HxChDF</td>
<td>0.1</td>
<td>&lt; 0.5</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>1,2,3,4,6,7,8-HpChDF</td>
<td>0.01</td>
<td>&lt; 0.5</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>OChDF</td>
<td>0.001</td>
<td>4.53</td>
<td>0.00453</td>
<td></td>
</tr>
</tbody>
</table>

It is clear (see the table № 4) that in a process of phenol destruction during the electrochemical generation of active chlorine there is a set of dioxins in a solution with the significant prevalence of 1,2,3,7,8 – pentachlorinedibenzo-dioxin (1,2,3,7,8-PChDD) and 2,3,7,8 – tetrachlorinedibenzo-dioxin (2,3,7,8-TChDD), which determine a toxicity in dioxin equivalent substances and which are the most toxic compounds. The concentration of 2,3,7,8 - ТХДД is within the limits of accepted in our country permissible concentrations (20 pg/l).
However, all 17 components shown in the table № 4 determine the total concentration of detected dioxins, which in dioxin equivalents is equal to 42.8 pg/l and exceeds accepted in Russia value more than twice.

In the light of all the preceding the evaluation of the risk for a process of phenol removing from a water by means of the electrochemical generation of active chlorine requires the additional investigations aimed at: 1) the detection of natural dioxin sources; 2) the determination of possible mechanisms of dioxin formation during the water chlorination, 3) the destruction of generated dioxin structures; 4) the extraction of these structures with the subsequent their burial, and the then in a case of synthesis during the chlorination process is quite perspective because of the high resistance of dioxin structures to every possible external effects.
Table 8.4.

Nature of the spectrophotometric analysis of polychlorinated dibenzodioxins (a = Cl(0)) and dibenzofurans (a = CdH(2)) in a sample of glass window, prepared by the "active" columns,

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial equilibrium</th>
<th>Concentration, pg/l</th>
<th>Concentration in DE, pg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,3,7,8-TCDD</td>
<td>0.5</td>
<td>22.15</td>
<td>18.14</td>
</tr>
<tr>
<td>1,2,3,7,8-PeCDF</td>
<td>0.8</td>
<td>96.2</td>
<td>82.0</td>
</tr>
<tr>
<td>1,2,4,7,8-PeCDF</td>
<td>0.7</td>
<td>84.6</td>
<td>72.7</td>
</tr>
<tr>
<td>1,2,4,6,7,8-HxCDF</td>
<td>0.1</td>
<td>6.7</td>
<td>5.5</td>
</tr>
<tr>
<td>1,2,4,6,8-HxyDF</td>
<td>0.9</td>
<td>4.6</td>
<td>3.6</td>
</tr>
<tr>
<td>0,99DF</td>
<td>0.6</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>7,8-DCDD</td>
<td>0.7</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>1,2,4,7-PCDF</td>
<td>0.09</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>1,2,4,6-PCDF</td>
<td>0.3</td>
<td>2.3</td>
<td>1.9</td>
</tr>
<tr>
<td>1,2,4,6,7-HxCDF</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>1,2,4,7,8-HxyDF</td>
<td>0.07</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>2,3,7,8-PCDF</td>
<td>0.07</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>DCDF</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

It is shown in the table 8.4 that in a process of thermal destruction during the electrochemical oxidation of organic chlorines there is a set of division in a solution with the photochemical pretreatment of 1,2,4,7,8 - polychlorinated dibenzofurans (5.5,7,8-PCDF) and 2,3,7,8 - polychlorinated hydrocarbons (1,2,3,7,8-TCDD), which eliminates a possibility in dividing equivalent substances and which are the organic compounds. The concentration of 2,3,7,8 - TCDD is within the limits of accepted in our country permissible concentrations (25 pg/l).
TRACK 2

SESSION 1

METHODS FOR TECHNOLOGICAL RISK
NUCLEAR COUNTERMEASURES UNCERTAINTIES ASSESSED BY EXPERTS

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ABSTRACT
Sheltering, evacuation and distribution of stable iodine tablets are considered to be major early countermeasure strategies to diminish the consequences after a release of radioactive materials from nuclear power plants into the air. The consequences, expressed in endpoints such as doses, risks and contaminated areas, are calculated with the help of accident consequence codes (e.g., COSYMA developed by the European Communities). These computer packages also contain modules to incorporate countermeasures strategies. In the codes countermeasures are taken once calculated doses are above preset intervention levels (doses defined by international bodies such as the IAEA). Whether in real situations emergency managers will act accordingly is hard to predict. Uncertainties associated with these decisions are termed "volitional" uncertainties. These uncertainties, however, cannot be assessed by expert judgements as they express the decision at stake in an emergency situation. Uncertainties on the times to implement countermeasures and on the times for the general population to respond to these measures can be assessed by experts, as they represent “lack-of-knowledge” uncertainties. This paper will describe the difference in approach of both types of uncertainties and will show the results of aggregating expert judgements on the latter type of uncertainties in early countermeasures strategies. Ten experts from seven European countries provided subjective assessments.

1. Introduction
Under the Third Framework Program of the European Union the EC/USNRC Joint Study [1] was initiated to further develop and apply expert judgement elicitation techniques to estimate the uncertainties associated with the predictions of probabilistic accident consequence assessment (ACA) codes. The uncertainties in the various aspects of consequence assessment modelling were considered separately by several expert panels. These panels were formed jointly with scientists from Europe and from the United States of America. Under the EC Fourth Framework Programme on Nuclear Fission Research a further study is conducted on the quantification of countermeasures whereby experts were invited to participate in a formal expert judgement procedure on the organisational and behavioural aspects of people in relation to possible emergency actions. This paper provides an overall picture of the expert panel considering "emergency actions".

2. CHOICE OF EXPERTS AND ELICITATION PROCESS
Ten experts from European countries (Belgium, Finland, France, Germany, the Netherlands, Sweden, United Kingdom) were selected to guarantee a wide diversity of expertise and
experience from various nuclear emergency situations. An initial training meeting was held in Delft, the Netherlands, on 19 and 20 October 1998. Following this meeting, the experts were given time to assess the elicitation questions. They were specifically not asked to use any methods used in the consequence code COSYMA, but were free to use whatever models or tools that they feel appropriate to answer the questions. They are encouraged, however, to write down all assumptions made and methods used during this process, together with a clear statement of all the uncertainties they have considered in the assessments. The elicitation sessions were carried out a few months later during a private meeting between the expert and a project staff member. Prior to the training meeting the questionnaire as given to the experts was discussed thoroughly with four nuclear emergency experts from France, Germany, United Kingdom and the IAEA in Vienna.

3. EXPERT JUDGEMENT ELICITATION

Expert judgements applicable for uncertainty analysis must be cast in the form of subjective probability distributions. Subjective probability measures degree of belief with respect to possible observations. In this study experts are asked only about physically observable quantities. For further details on the applied methodology, we refer to Cooke [2].

Degree of belief is elicited in the form of 5%, 50% and 95% quantiles of subjective probability distributions. The 5% quantile of the distribution for an uncertain quantity X is the number \( x_{0.05} \) such that \( \Pr(X < x_{0.05}) = 5\% \). For each assessment, certain background information is supplied. It is not the intention to provide all physically relevant information; rather the information provided corresponds to the information which accident consequence code models require. For example, to predict the effects of emergency actions, the standard deviation of the number of people in a designated area is relevant physical information. However, the models in question use only a stated single number of people to determine the emergency actions effects. Hence only this information is provided. The expert's uncertainty must therefore take into account only the possible physical realisations under the stated conditions.

4. SCOPE OF THIS EXPERT PANEL

This panel has been convened to consider the issues relating to the uncertainties in implementing emergency actions, such as sheltering, evacuation, relocation, forced land decontamination, skin decontamination, distribution of stable iodine tablets, and food restrictions. The questions posed will refer to the behaviour of people directly or indirectly affected by emergency actions or groups of them in the time periods before, during and after the implementation of emergency actions. In the expert panel the organisational and behavioural aspects of emergency actions are the main subject. Only the following emergency actions were elicited by this panel: sheltering, evacuation, the intake of stable iodine tablets, and driving times to leave an evacuation area.

Emergency guidelines distinguish between three types of emergency actions:
1. General emergency: take action immediately
2. Site area emergency: crisis team, but no immediate action, only when declared later as a general emergency
3. Alert: only notification to authorities.
For a full understanding of what is meant in this context by the emergency states, one is referred to the IAEA document [3] of which the relevant pages were handed out to the experts.

The accident sequence is defined with the following points in time and time periods:

\[ t_{al} \quad t_{pa} \quad t=0 \quad t_{ae} \quad t_{ep} \quad t_{pc} \quad t_{ooa} \]

\[ T_{not} \quad T_{org} \quad T_{beh} \quad T_{dr} \]

Explanation of the points in time: The sequence starts with the time at which the initiating event sufficient to declare a general emergency is observed (\( t_{al} \)) followed by the time at which the plant officials notify the responsible authority about a general emergency (\( t_{pa} \)); this time period is called notification period (\( T_{not} \)). Note that \( t=0 \), which is the time of release of radionuclides can be at any place on the time sequence. Next period is the time to organise, having two points of time: the time at which the responsible authority notify the local emergency staff (police and so on) to start taking countermeasures (\( t_{ae} \)) and the time at which the local emergency staff notifies people to follow up countermeasures (\( t_{ep} \)). Next a period of response by people (\( T_{beh} \)) is followed, ending with the time at which people act on countermeasures and start preparing evacuation (\( t_{pc} \)). The last period (for evacuation only) is the period to leave the evacuation area (\( T_{dr} \)) ending with the point of time to go out of the area where countermeasures are active (\( t_{ooa} \)).

The emergency planning zone is defined as a segment or circle, based on fixed distances from the plant (2 to 5 km from point of release) where sheltering and evacuation takes place. Besides that two areas were defined, both outside the emergency planning zone, one within 30 km of the site (a segment or circle, where sheltering and evacuation takes place) and one outside 30 km of the site: segment, where only sheltering takes place. For administration of stable iodine tablets an area around the plant is taken determined by the dose to the thyroid being above the threshold value. Stable iodine tablets are taken only once by people. Two situations are distinguished. They can either be pre-distributed to the people and they have them at home, or the are stocked in distribution facilities and distributed in cases of an emergency.

5. COGNITIVE VS VOLITIONAL UNCERTAINTIES

In particular in the countermeasures modules of codes, the target variables are not only of a physical nature, but are (fully or partly) determined by decision making in emergency circumstances or by political considerations. In the project three types of uncertainties are distinguished: stochastic uncertainty caused by non-deterministic physical processes, cognitive uncertainty caused by lack of information regarding intrinsically deterministic processes, and volitional uncertainty caused by lack of knowledge regarding what one wants or intends to do. Of these, stochastic and cognitive uncertainties can be measured and (in principle) be observed in the real world, and can thus be represented as subjective probability. Target variables can be phrased in the form of unambiguous elicitation variables.

The volitional uncertainty cannot be represented straightforwardly as subjective probability. The reason for this is that subjective probability is operationalised as "willingness to wager".
In wagering on one's own volition, the volition is obviously influenced by the stake of the wager itself. This makes it impossible to speak of a degree of belief with regard to intentions and volitions, independent of the method of measurement. Although willingness to wager can be regarded an observable quantity, it is related to own decisions which means it influences the decision maker's behaviour. For that reason one cannot apply expert judgement to acquire volitional uncertainties.

Uncertainties of parameters which are fully volitional cannot be assessed by (emergency response) experts even if they have the expertise for the behaviour of emergency managers adequately. Uncertainties of parameters which are partly cognitive can be assessed by (emergency response) experts who are able to assess the behaviour of large populations or organisations adequately. In essence, these parameters are not determined by emergency managers' decisions, and need to be addressed by the expert panel.

Two issues apart from behavioural aspects are relevant with respect to emergency actions. The first issue concerns any procedural aspects prior to making a decision on, e.g., whether or not to evacuate. Procedural aspects might be measurements in the field. The second issue concerns operational aspects after the decision to implement an emergency action is made. E.g., in cases of evacuations, it takes time for emergency workers to enter the affected area with the necessary equipment. Driving times can be considered operational aspects as well. The uncertainty on the decision making aspects is volitional, but the uncertainties on procedural and operational are only partly volitional and partly of stochastic/cognitive nature.

6. OVERALL PICTURE OF RESULTS
All experts' data have been collected. In this section only the overall findings are presented. Following the accident sequence time periods from section 4, for the first period (time to notify the authorities ($T_{\text{not}}$)), two groups of responses are found: 3 experts assessed relatively short periods of time, several minutes, while the other 6 experts assessed longer periods with large uncertainties, half an hour to 2 hours. For the time to organise emergency services and notify the people ($T_{\text{org}}$) large differences in assessments are found, with median values ranging from 1 to 3.5 hours, having assessed 5th and 95th percentiles ranging from 10 minutes up to 6.5 hours, all for sheltering. In cases of evacuations, similar patterns were assessed with even larger periods of time.

Next period of time is to implement the emergency actions by the people ($T_{\text{beh}}$). Again, differences are given with median values ranging from 10 minutes to 3 hours, in cases the notification to evacuate as instructed by the authorities, is followed by people. Somewhat smaller values are given in cases people do not follow the instructions of the emergency services, but find their own way of evacuation. Driving times are very locally determined and vary from 6 minutes (5th percentile value) to 0.5 to 1.5 hours for median assessments and 1 to 4 hours for the 95th percentiles.

Finally, taking in stable iodine tablets takes 10 to 20 minutes when already available at home with 95 percentiles up to 3 hours (!), and 50 to 70 minutes when distributed at special facilities, again with high 95 percentiles (up to 12 hours).

In general, large differences between experts' assessments are found mainly because they are all based on local situations with own local infrastructures. Further analysis of the data will be published by the European Commission [4].
Acknowledgement
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A HAZARD EVALUATION TECHNIQUE
TO PREDICT ACCIDENT AND EXPOSURE SCENARIOS

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ABSTRACT
The Safety Science Group has developed a hazard evaluation technique, using the format of the HAZard and OPerability Study (HAZOP). The technique is able to predict accident and exposure scenarios for new or existing technologies. In that respect it differs from the traditional HAZOP technique, which is primarily focussed on loss of containment. With various research-project experience is gathered with the technique in the steel industry and the building industry, applying the technique on methods of work, on installations, and technologies. Evaluation studies were performed to test the robustness of the technique. The predictability of accident and exposure scenarios is of great importance and provides an opportunity to reduce health and safety hazards and risks during the design of installations or technologies.

INTRODUCTION
Most accidents are predictable in retrospect. The proportion of accidents that can actually be foreseen can be assessed in part by using hazard identification and risk assessment techniques. Such techniques are not meant to predict specific accidents, but enable the analyst to identify accident scenarios and to estimate the probability of their occurrence and their related consequences, such as the number of casualties.

Hazard identification in the (re-)design of production organisations is an important tool for managing safety, health, and environment in enterprises. Various methods of hazard identification can be used. One such technique, the HAZOP technique, developed by ICI, has been used widely in the chemical process industries.

The HAZOP technique is well developed and has been applied in process flow systems for identifying potential deviations from design intent and for developing both hardware and procedural solutions to counter these deviations. In the literature several variants of the HAZOP technique have been published. Including proposed modifications in the list of guide words, to give a better fit for the process parameters (CCPS, 1992; Harms-Ringdahl, 1993). Other publications describe applications of the technique to non-process flow systems, like maintenance activities (Raman, 1991), or on the alteration of the HAZOP technique in favour of human error identification (Kirwan, 1992).

The Safety Science Group of the Delft University of Technology has developed a hazard evaluation technique, using a HAZOP format. The aim of the technique is to elucidate and rank accident scenarios according to their frequency of occurrence. The hazard evaluation technique is applied in a steel works and the building industry, being branches of industry outside the process industry.
HAZARD EVALUATION TECHNIQUE IN A STEEL WORKS

In the steel works, the hazard evaluation technique was used in a safety study of a steel converter plant (Bakker, 1993). The safety study was part of a larger study on safety management of the steel works (Swuste et al, 1993; Swuste et al, 1999). In the steel converter plant a so-called ladle arc furnace was introduced, a complex installation. Management of the steel converter plant was eager to get a grip on possible accidents during disturbed process conditions of the ladle arc furnace. The attention to disturbed process conditions was justified from the plants’ experience with previous installations, where the majority of accidents occurred during these process conditions. Neither at the steel converter plant nor at the steel works any experience was available with this installation with any similar type of installation.

Presentation used

Instead of using detailed engineering diagrams, e.g. piping and instrumentation diagrams, as is common in HAZOP studies, construction drawings of the installation were used as presentation for the study, completed the results of a design analysis. The design analysis resulted in a set of separate processing operations, using a classification of the installation into logical sections on the basis of the material flow (Swuste, 1996). The following processing operations were distinguished:

- transport towards and from the ladle arc furnace;
- processing operations, heating charge, mixing raw materials;
- sampling temperature and steel quality.

Process parameters and guidewords

From the HAZOP format the following process parameters and HAZOP guidewords were found to be relevant during the study:

- process parameters: transport, level, flow, temperature, sampling, operation, reaction, voltage, pressure, cooling.
- guide words: no/not, less, more, as well as, other than.

RESULTS

The application of the technique in the steel converter plant was aimed towards predictable accident scenarios during process deviations of the ladle arc furnace, which were generated by the participants of the study; supervisors, workers and plant managers. In two sessions the group generated a list of possible accident scenarios and listed the scenarios in categories of frequencies of occurrence. Because no former experience with ladle arc furnaces was present the group had to rely on the expert judgement of all members. Particular the very different composition of the group both in official status within the organisation as in field of expertise proved to be very stimulating. Although this technique is aimed at design changes of the installation based upon predicted accident scenarios, this option was not possible. The construction of the installation had already started at the time the group-meetings took place. This opened the opportunity to validate the accident scenario's predicted. For a period of two years after the study was finished, workers of the ladle arc furnace kept a logbook to note all process deviations (450 in total). 58 % of all predicted process deviations and consequent accident scenario's occurred. Of the remaining deviations two third could be grouped afterwards under three scenarios related to maintenance activities (Swuste et al, 1997). These results were very positive, because study showed the robustness of the technique applied.

HAZARD EVALUATION IN THE BUILDING INDUSTRY

The hazard evaluation study in the building industry was conducted in the specific area of road construction works. The study aimed generate and to rank possible accident scenarios for this group of workers. Surprisingly both in national and international literature hardly any...
research findings are reported related to this group of workers, despite the great volume of literature related to traffic safety during road construction works.

For the purpose of the study the traffic passing by a road construction work was seen as a stream of cars, as a 'process flow'. The root scenario defined the disturbed process flow: 'ROAD WORKER COMES INTO CONFLICT WITH TRAFFIC'. This root scenario was further divided into two parts: the conflict was a result of either traffic coming into the construction section of the road or road workers entering the traffic section of the road. Special attention was given to situations at the start or the finish of construction work. Under those conditions the construction section is not defined yet and road workers are plotting or removing the boundaries of the section. The study was conducted at three types of roads; the highway, the provincial roads and roads of build-in areas.

**Presentation used** The presentations used in the study were official drawings of road construction works, issued by the Ministry of Transport and Public Works for the types of roads under study. At each road a variety of traffic conditions were used; e.g. intersections, exits, straight road sections, roundabouts etc., as well as a variety of construction work carried out.

**Process parameters and guide words.** The process parameters were divided into two parts; parameters for traffic behaviour and parameters related to road conditions.

- **Process parameters**
  - traffic behaviour; speed, direction, conflict.
  - Road conditions; route change during start or finish of working section, manoeuvre space, sideways, traffic conduction measures - route change and behavioural change (e.g. speed reduction).

- **Guide words**
  - no/not, more, less, better, worse; simultaneously, partly, reverse, other than.

**RESULTS** In two sessions the participants of the study, being road construction workers, road owners and designers of road construction works, have generated a list of scenarios and ranked the scenario’s in categories of frequency of occurrence. The list was used during a field study of two months, where road workers participating in the study, scored the scenarios which actually occurred during road construction work. The field study provided a second list of scenario’s as well as an actual frequency of occurrence. Unfortunately the Spearmans rank correlation between the two lists was very poor, from negative (-0.09 built-in areas) to 0.04 for highways and provincial roads (Swuste and Heijer, 1998).

**DISCUSSION**
The results of the study in the steel converter plant were encouraging. By combining accident scenarios and frequency of occurrence of deviations, the HAZOP study was not restricted to prospective hazard evaluation and assessment only, but included a risk assessment as well. Furthermore, the technique is simple, involves teamwork and is not an 'expert tool'. The close co-operation between designers, representatives from service and production departments, and the shop floor creates a transfer of knowledge, experience and opinions. The technique, in combination with the design analysis, is an effective method for hazard identification, evaluation and risk assessment in complex installations, plants, or processes where the technology is revolutionary for the company and no past experience with similar installations is available.

The study in the building industry was less promising. This was partly due to the short period of the fieldwork and to the variety of activities under study. The field study included relatively
simple road works like mowing roadside grass, placing traffic signs and larger construction works, like road repairment and redesign of road exits. As the study in the steel converter plant showed, a defined set of processing operations is a suitable study object. For the road works, not only the type of road but the combination of type of road and processing operation must be the selection criterion.

The technique is now applied in a second study in the building industry, the construction of drilled tunnels. During this study also the exposure to chemicals, noise and physical stress is incorporated in the study design. These hazards are not only present during disturbed process conditions. A special alteration is made to include the assessment and evaluation of these hazards during undisturbed process conditions. Although the study is not finished yet, the results are promising.

In conclusion, by its nature the hazard evaluation technique can contribute to health, safety, operability and environment, for it identifies ‘adverse events’ of any origin and provides a structured approach to semi-quantification of the hazards.

REFERENCES
HANDBOOKS FOR ASSESSING THE RISK OF ACCIDENTS INVOLVING HAZARDOUS MATERIALS IN THE NETHERLANDS

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ABSTRACT
For more than twenty years the Dutch government has been developing methods for calculating the risk of accidents involving hazardous materials, in close co-operation with private industry and research institutes.

INTRODUCTION
In the Netherlands the distance between residential areas and industrial areas is often rather small, because the country is small, densely populated and heavily industrialized. In the early 1970s there was serious concern about the risk of accidents in industries that use or produce large quantities of hazardous materials. An interdepartmental Committee for the Prevention of Disasters (Dutch abbreviation: CPR) started to issue a large number of guidelines and instructions about industrial equipment and the handling of hazardous materials. This was done in close consultation with technicians and scientists from industry and from research institutes. However, the committee soon realized that it was impossible to exclude all risks and that it was necessary to develop generally accepted methods for risk analysis in order to be able to judge and evaluate accident risks in a rational way.

RISK ANALYSIS METHODOLOGY DEVELOPMENT
As industries using hazardous materials had to obtain operating licenses from the authorities, they had to enter into discussions with the authorities about the possible physical effects of the release of hazardous materials and of explosions and fires. The CPR installed a subcommittee on Risk Evaluation (CPR-RE) in 1977. Esko Blokker has been a member of this committee from the beginning and became its chairman in 1981. The unique aspect of the CPR-RE is that industry representatives participate in it. All methods and models are worked out in working groups, the CPR-RE takes the final decisions and then the CPR publishes the risk calculation methods.

Physical Effects, The Yellow Book
The TNO research institute was commissioned to develop methods for calculating the physical effects of releases of hazardous materials. The methods they presented in their report were initially criticized by industrial experts, but after a period of close cooperation TNO and industry were able to reach a consensus. Because of the report's cumbersome long title everybody calls it the "Yellow book", after the colour of its cover. Originally the idea was that the methods could be used by a technical generalist using only a calculator. In later editions this idea was abandoned and several of the methods are now so complex that they can only be applied by an expert using dedicated computer programs. The Yellow Book presents methods for the calculation of outflow and spray release, pool evaporation, vapour cloud dispersion,
(un)confined vapour cloud explosion, heat flux from fires, rupture of vessels and methods for combining the different models to obtain an integrated calculation of, for example, outflow, dispersion, cloud ignition and explosion.

Risk Analysis, the COVO Study
Public concern about the risk of serious industrial accidents was particularly grave in the Rijnmond region, the industrialized area around Rotterdam. In 1977 the local authorities formed a Committee for the safety of the population (Dutch abbreviation COVO). It discussed the possibility of introducing risk analysis as an instrument for managing the industrial hazard issue. A COVO Steering Committee was formed, chaired by Mr Blokker. Its task was to investigate the possibilities and limitations of quantitative risk analysis applied to chemical process industries. Until then quantitative risk analysis had been applied mainly in the nuclear energy industry. The consulting engineers Cremer and Warner were commissioned to develop and test methods for risk analysis on six potentially hazardous industrial objects in the Rijnmond area. Battelle was asked to provide a second opinion. Experts from the industries concerned also participated in the COVO Steering Committee and contributed by making available their expertise and critically reviewing proposals. The study was completed in 1981 and the results were published in 1982[2]. This report, too, has a very long title, so everybody calls it the COVO study. Many of the concepts and methods developed in it are still used by risk and safety policymakers in the Netherlands. The report introduced the concepts of individual risk and group risk in the Netherlands. It discusses not only physical models, such as the ones described in the Yellow Book, but also models for toxicity, vulnerability and probability calculations. It describes in detail how the risk calculations were made.

Consequences and Damage, the Green Book
It is a very difficult task to estimate the effects of explosions, fires and toxic gas releases on people. Still, such estimates are essential for quantitative risk analysis. The subcommittee on Risk Evaluation, CPR-RE, therefore commissioned TNO to collect and develop such methods. These were then reviewed and improved by industrial and governmental experts and finally published as the Green Book[3]. The Green Book contains chapters about damage caused by heat radiation, the consequences of explosions for structures and humans, hazardous substances which can be released during a fire, damage caused by acute intoxication, and protection against toxic substances.

Probabilities, the Red Book
In order to estimate the risks of accidents, it is necessary to carry out probability calculations. It is also necessary to collect failure rate statistics and reliability data. The Subcommittee on Risk Evaluation, CPR-RE, commissioned TNO to collect and develop methods derived from probability theory to be used in risk analysis. The result was the first edition of the so-called Red Book[4]. The second edition was edited by the KEMA research institute. Both editions were critically reviewed by industrial and governmental experts. The book contains chapters about probability definitions, probability theory, statistics, reliability theory, data analysis, methods for identification of failure scenarios, fault tree analysis, quantification of cut sets, event tree analysis, Markov processes, accident sequence development and quantification, dependent failure analysis, human failures, uncertainty, importance and sensitivity analysis, reliability, availability and maintainability specification and maintenance optimization.
GOVERNMENT POLICY AND RISK ANALYSIS METHODOLOGY

Under the influence of the COVO study and other Dutch studies into the risks of large scale handling of liquefied natural gas (LNG) and liquefied petroleum gas (LPG) the national government and the provincial governments in the Netherlands developed a risk policy including standards for acceptable risks. The former Dutch Environment minister, Mr Ginjaar, introduced the concept of "external safety", which is the safety of the population outside of the company. The first post-SEVESO Directive of the EU was implemented in the Netherlands in such a way that industries that handled large quantities of hazardous materials were obliged to present an "external safety report" to the authorities, which should include a quantitative risk analysis of the most hazardous installations in the form of Individual Risk contours and Group Risk curves. Other legislation in the Netherlands required the presentation of "occupational safety reports" (Dutch abbreviation: AVR), which are reports on the safety of the employees within the company. The practical implementation of this legislation led to numerous discussions about interpretations, assumptions to be made and models to be used in risk analyses. These discussions were very important because the Dutch government introduced the concept of “acceptable risk”: if a risk was higher than the acceptable level, the industry had to reduce this risk, or it would lose its permit. All these issues were resolved by a technical committee in which technical experts from industry once again played an important role. Other important members were representatives of the provincial governments that issue the environmental licenses to industries after approval of the external safety reports. Virtually all resolutions adopted by this committee were consensus-based, which means that both industry and the authorities committed themselves to using the risk analysis tool for practical policy decisions. The technical committee was later merged with the Subcommittee on Risk Evaluation, CPR-RE. The need was felt to develop a similar risk policy for the transportation of hazardous materials. The Netherlands is densely populated and many of the main transportation routes (by road, inland waterways or rail) go through residential areas. So in several committees and studies a risk analysis methodology for the transportation of hazardous materials was developed and in this case, too, standards for acceptable risks were introduced. The total number of resolutions on how risks should be calculated had by now become very large and rather confusing. It was unavoidable that the accepted methods were not entirely consistent. At the same time, the revised post-SEVESO Directive of the EU forced the Netherlands to review its own safety and risk legislation. The outcome of this review was that the “internal” AVR and the “external” SEVESO safety report will be integrated into the SEVESO II Safety Report.

Guideline for Quantitative Risk Assessment, the Purple Book

In order to integrate all previous resolutions on how risk analysis has to be carried out in the Netherlands, it was decided to draw up a Guideline for Quantitative Risk Assessment. The CPR-RE installed a working group, chaired by Frederik Bruning, to review all previous resolutions. The RIVM research institute was commissioned to draft the first part of a guideline for stationary installations, which was then reviewed and discussed by the working group. Again, the working method was to reach a consensus between experts from the industries and experts from the different ministries and regional authorities. The second part of the proposed guideline, the transport part, was prepared by SAVE Consulting Scientists. The resulting book has been accepted by the CPR-RE and has been submitted to the CPR for publication, hopefully in 1999[5]. The book, although not yet published, has already been dubbed "the Purple Book". Although written for use in the Netherlands, the Guideline contains a lot of valuable information for risk analysts anywhere in the world. It starts with a selection system: only the most hazardous installations have to be analyzed in detail. It goes
on to describe loss of containment events, modelling source terms and dispersion, exposure and damage and calculation and presentation of results. Subsequent chapters are about quantitative environmental risk analysis (obligatory according to Dutch legislation), the use of new models and uncertainty in QRAs. The transport part describes the selection of routes and the calculation of transportation risks according to a quick and practical model developed for an inter-province council. The Purple Book reviews the state of the art in quantitative risk analysis in the Netherlands. The models and assumptions are not entirely consistent, but they are reasonably reliable. If groups of research scientists, government experts or industry experts had developed the models independently, without consulting one another, the models might have been "reliably unreasonable". In order to be useful in government practice, risk analysis cannot be purely scientific. Assumptions have to be made and agreed upon. When new models are chosen, this has consequences for government policy and the issuing of operating permits. Therefore, progress is slow and consensus is essential.

This is the present state of affairs. Review work on the Green Book is in progress and studies have been started to solve some of the remaining questions in the Purple Book. Together, the Coloured Books contain a wealth of information on the art of quantitative risk analysis.

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TRIPOD DELTA:  
DETECTING ORGANISATIONAL VULNERABILITY  
BY  
MAPPING OPERATIONAL PERFORMANCE  

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"Six months after they began using Tripod, their accident rate had fallen by 30%."  
(Phil Watts, Managing Director of the Royal Dutch/Shell Group, 1999)  

TRIPOD; THE CONCEPT  
The Tripod theory recognizes 11 determinants, which are critical to the level of control in an organisation. These determinants are called BasicRiscFactors (BRFs). The level of control of these BRFs is indicative for the quality of the management of all business/production processes in different types of organisations (Figure 1).  

![Figure 1: BasicRiscFactors](image1.png)  

![Figure 2: Aspects of BasicRiscFactors](image2.png)  

The Tripod theory has served as basic concept for a method to measure the performance (read: level of control on processes) of an organisation. This method is called Tripod Delta Survey and is designed to detect weak areas in the environment in which people are operating. The survey uses questionnaires to collect data relating to factual verifiable operational experiences.  
In order to adapt the survey to the practical requirements of the end users, the relative abstract BRFs are each subdivided into 4 aspects (Drivers, Resources, Methods and Output). Each individual aspect is addressing a specific organisational level responsible for the quality of the aspect concerned (Figure 2).  
Survey results are presented in a quantitative (a graphical profile) as well as in a qualitative way (a textual explanation about what aspect is weak/strong).
FIELD EXPERIENCE

During an extensive (4 years) field test period a question library (DeltaBase) has been compiled and calibrated to ensure the required level of reliability and validity of the survey results. The method has shown to be of added value to organisations that are interested in their level of organisational vulnerability. Tripod Delta Surveys have been successfully utilized in different settings (different types of industries in various geographical areas).

The application of Tripod Delta Surveys in organisations has shown that survey results presented on aspect level give clear and tangible information to strategic as well as operational management. This information has proven to be a sufficient basis for the people who are responsible to develop an improvement plan for a particular area of operation, which has shown to be relatively weak. The results can also be used to avoid overspending of money in relative ‘strong areas’.

CONTROLLABLE TARGETS

By the pro-active nature of the method it enables organisations to determine controllable performance targets, without having to rely on the results of accident analyses. This approach enhances "preventative thinking" instead of the more traditional mode of "corrective thinking". Achieved results of interventions can be measured over time to verify improvement as well as for benchmarking. So people are held accountable the quality of the results of planned interventions (improvement plans). By this means people are able to control their performance by the way they conduct their planned actions. This enhances workforce involvement for all staff positions.

QA/QC PROTOCOL

The method addresses the latent "underlying" factors of operational processes. As such Tripod Delta Surveys are considered as an organisation focused add-on to existing inspection, audit and other existing evaluation techniques.

The know-how of the developing partners of this survey is vested in the Stichting Tripod Foundation. Exploitation is delegated to Tripod International BV and its Providers (consultancy firms accredited by Tripod International to conduct Tripod Delta Surveys).

A strict QA/QC protocol (supervised by Leiden University) serves as safeguard over the quality of survey results. All survey reports include a quality statement related to the reliability and validity of the survey results.

THREE CASE STUDIES

1. Reducing the completion time for questionnaires

In order to reduce the time needed to complete questionnaires these are split into different sub lists containing a limited amount of questions. Sub lists cover a reduced number of BRFs. By a careful design all sub lists together cover all 11 BRFs, one BRF is represented on all sub lists and serves as "anchor BRF" to verify whether there are no significant differences in response patterns over the population.

The sub lists are randomly distributed over the response group (e.g. operational staff of a factory).

In case the design is right and the groups are truly representative for the organisation surveyed, the profile scores of any randomly selected sub group (batches) from this
population should be similar within acceptable tolerances. This should also be the case with the cumulative distribution of the profile scores of the batches in question, which means that the different batches have about the same amount of respondents returning low profile scores and the same amount of respondents returning high profile scores. These two conditions (similar profile scores and similar distribution) are both required in order to state that all sub lists distributed over these random selected batches are truly indicative for the state of affairs in the organisation surveyed.

In the case of company "A" the questionnaire was split into 4 sub lists which were randomly distributed over the group "operational staff". Every sub list contained the 25 questions of BRF Procedures (the "anchor BRF"). The survey covered a group of 240 people working on 15 different work sites controlled by one organisation. Below the results of this test are presented.

![Figure 3](image1.png) ![Figure 4](image2.png)

Figure 3 shows the profile scores of the 4 different batches. The profile scores do not differ significantly (75 ± 2, n.s.). Also the distribution of the scores of the different batches does not differ significantly (Figure 4 presents the cumulative distribution).

Conclusion:
Reduction of response time by splitting up Tripod Delta questionnaires (respecting certain statistical requirements) will not reduce the quality of the survey results.

2. Measuring the results of interventions; the validity and reliability of the method
The effects of Tripod interventions (validity) can be measured in two ways:
No difference in profiles, in case there have been none or unsuccessful interventions
Improved scores in those areas where interventions have been successful.

Test-retest reliability of a survey is established by comparing profile scores of the same population obtained by different checklists.

Company B: No successful interventions
Company "B" has been surveyed the first time in 1996. Based on the survey results an
ambitious plan was designed to improve the score on the weakest BRF (Maintenance Management, MM).

After 3 years the management requested a second survey to verify whether planned interventions had positive effects on the company's performance. The re-survey showed no significant improvement in the area of maintenance (Figure 5). In depth investigation, triggered by the outcome of the survey, showed that the potentially effective improvement plan had been kept securely in a drawer after it had been presented to the management.

Conclusion:
Tripod Delta Surveys also indicate when improvement plans are NOT implemented.

Company C: Successful interventions

Company "C" was surveyed in 1997 and invested a substantial amount of money in Maintenance Management as the survey showed this BRF as being the weakest area.

To verify the effect of this investment in Tripod terms, the company decided to conduct a re-survey on this BRF only, using a questionnaire with twice as much (50) questions. A set of 25 questions identical to the first survey, and another set of 25 questions which were never asked in this company before. All questions were drawn from the calibrated Tripod Delta question pool (DeltaBase) and mixed into a single questionnaire. As such this survey design complies with the requirements to test the test-retest reliability of the survey method. Comparison of the 1997 and 1999 surveys show the effect of the investment: a significant increase in scores measured by both question sets (Figure 6).

The high level of test-retest reliability of the Tripod Delta Survey can be deduced by comparing the 'MM Question set 1' and 'MM Question set 2' results in Figure 6. Both lists give equal profile scores, showing that survey results are independent of the specific set of questions used and indeed indicative of the level of control an organisation has over this BRF.

Note: The above applies only for sets of calibrated questions drawn from the Tripod DeltaBase.

Conclusions:
1. Successful interventions aimed at improvement of weak BRFs result in a substantial increase of the BRF score.
2. The test-retest reliability of Tripod Delta Surveys is acceptable.

To conclude
The scientific approach of the Tripod Delta survey method eliminates the influence of the (subjective) views of individual auditors or inspectors. Survey results are determined by straight forward statistical processing of data without otherwise inevitable human bias.
This makes Tripod Delta a reliable method to conduct benchmark studies between different organisations.

Benchmarks have been established already in the railways as well as in the drilling industry. At the time this paper is written an extensive survey is conducted in the shipping industry. The method has repeatedly shown to be valid and reliable.

The results presented in this paper confirm an earlier study by Shell Expro in Aberdeen. In this study it was shown that Tripod Delta Surveys provide useful recommendations at a fraction of the costs of ‘traditional’ audits (Pearce, 1996 and 1997). The results of a Tripod Delta Survey form a sound basis for interventions aimed at improving the level of management control in a company.

LITERATURE

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Groeneweg, J and Roggeveen, V.  

Pearce, A.J.  

Pearce, A.J.  


Data shown in Figure 8 indicate that the company’s risk analysis methodology has improved since 1995. The data show a significant decrease in the number of incidents reported in the last two years compared to the previous years. This improvement is also reflected in the company’s overall risk profile, which has become more stable.

Figure 8: National Waterways Management Corporation (NWMC) Risk Analysis

Conclusions:
1. National Waterways Management Corporation (NWMC) has demonstrated a significant improvement in its risk analysis methodology.
2. The company’s risk profile has become more stable over the last two years.

The data presented in Figure 8 indicate that National Waterways Management Corporation (NWMC) has made substantial progress in its risk analysis methodology. The company’s risk profile has become more stable, and the number of incidents reported has decreased significantly in the last two years compared to the previous years.
ANALYSIS OF RISK RESEARCH ACTIVITIES WITHIN SRA-EUROPE

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ABSTRACT

In the paper the presentations of the annual meetings of the SRA Europe are used as an indicator for the development of the SRA-Europe. The SRA-Europe is a network of people working in the field of risk analysis in Europe. The network is organized in national risk analysis networks. The main objective of the network is to encourage the exchange of knowledge and experience in the field of risk analysis as well as providing a forum for the exchange of ideas and information. The network is funded by the European Commission through the SRA-Europe project.

INTRODUCTION

The SRA-Europe project is a network of risk analysis professionals from Europe. The network aims to promote the exchange of knowledge and experience in the field of risk analysis as well as providing a forum for the exchange of ideas and information. The network is funded by the European Commission through the SRA-Europe project.

TRACK 2

SESSION 2

METHODS FOR ENVIRONMENTAL HEALTH RISK
TRACK 2

Session 1

METHODS FOR ENVIRONMENTAL HEALTH RISK
ANALYSIS OF RISK RESEARCH ACTIVITIES WITHIN SRA-EUROPE

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ABSTRACT
In this paper the presentations at the annual meetings of the SRA-Europe are used as an indicator for the development within the field of risk analysis, particularly in Europe, the last decade of this century. The total number of papers presented increase in average with 40 per year. This is based on growth within all risk topics. In the early period a relatively large number of papers on industrial risk, infrastructure and transportation were presented, being replaced by an increasing number of papers on environmental risk and nuclear risk from 1995 onwards. In general, the relative number of papers presented on "new" risk topics are increasing, emphasising the multidisciplinary aspect of risk analysis. Surprisingly, the number of papers presented on risk in relation to the newly established and intensely growing industries, biotechnology and information technology is still limited. Also the number of papers on human toxicology is limited. Finally, the number of topic independent papers is increasing. This indicates that risk analysis is becoming a stand alone field of study. Also the increasing number of papers submitted confirm this development.

INTRODUCTION
The Society for Risk Analysis (SRA) was founded at the end of the 1970s in the United States of America and is the main professional body for risk analysis (professionals). SRA publishes an international journal: Risk Analysis since 1981. European professionals in risk analysis have participated (modestly) from the beginning, until 1987, when SRA erected its own European chapter. Since 1988 SRA-Europe has its own international scientific journal: the Journal of Risk Research. Marc Poumadere describes the European chapter’s first ten years history in the first issue of the journal [Ref. 1]. It should be noted that other conferences (like the annual European Safety and Reliability Association (ESREL) and three-yearly Probabilistic Safety Assessment and Management (PSAM) meetings) also deal with risk analysis albeit from a somewhat different perspective, dominated by technical and risk management issues.

SRA-Europe is an interdisciplinary professional society concerned by every dimension of risk analysis, including risk assessment, risk management and risk communication. It brings together all individuals and organisations concerned with risk analysis, risk problem solving and risk regulation in Europe. Its membership is multidisciplinary and comprises engineering risk and safety analysts, biologist, chemists, toxicologists, health scientist, social scientists and risk regulators, policy formulators and industrialists. It provides a platform for academics, industry and policy makers to discuss both the state of the art and future directions in the expanding and multidisciplinary study of risk analysis. The SRA-Europe is represented in 25 European countries and has had eight annual conferences held in Vienna (1988, 1990), Paris (1991, 1998), Rome (1993), Stuttgart (1995), Guildford (1996) and Stockholm (1997). The next annual conferences are planned in Rotterdam (1999) and Edinburgh (2000, jointly with ESREL).
METHODOLOGY
The Journal of Risk Research and the annual meetings eventually cover essential developments within the field of risk analysis in (mostly) Europe. In this paper the proceedings from the annual meetings of the SRA-Europe are used as an indicator for the development within the field of risk analysis in Europe.

At each conference important risk issues have been identified and the papers submitted are clustered in sessions around these issues. Across the sessions topics of interest and development can be identified. These topics are related to the source of risk, the risk activity or the risk receptor and are as such often connected with a scientific discipline. Sometimes whole sessions are dedicated to a specific topic, but mostly the issues for the sessions are of a more general character, such as risk management, risk perception or methodology. The clustering of the submitted papers around a particular issue provides an excellent possibility for risk analysts to get inspiration from other scientific disciplines.

Within the eight annual conferences 13 topics have been identified. The topics are industrial risk, nuclear risk, environmental risk, infrastructure/transport, food risk, occupational risk, economic risk, natural disaster, medical health risk, biotechnological risk, animal health risk, information safety and human toxicology. For some papers no classification was possible (ncp). Some topics must be viewed in a broader sense. Industrial risk thus includes risk from various technologies, industrial processes, accidental release of hazards from industrial plants, offshore activities, waste incineration, energy production, electromagnetic radiation from overhead power lines, mobile phones and risk minimisation from improved computer interfaces. Nuclear risk includes all kinds of risk associated with nuclear power plants and risk from radioactive substances. Environmental risk includes ecotoxicology, risk for ecosystems and humans from chemicals in the environment (e.g. pesticides), climate change and environmental policy issues. Infrastructure/transport covers risks from traffic, transport and storage of hazards, pipelines, regional industrial infrastructure, siting of waste facilities, air traffic, construction work, water dams, risk within buildings and stability of energy supply. Food risk includes drinking water, alcohol and smoking. Occupational risk includes traditional HSE topics. Economic risk covers cost-benefit approaches and insurance issues. Natural disaster includes earthquakes, flooding, fire, etc. Medical health risk includes public health risk (risk from virus and bacteriological infections) and mental health risk. Animal health risk also includes agricultural “health” risk. Human toxicology includes animal testing, dose response curves, animal human extrapolations and epidemic studies. In table 1 and in figure 1 the numbers of papers on each topic is presented. Figure 2 shows the relative number of papers presented on each topic.

Table 1. Number of papers at SRA-Europe conferences.

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RESULTS AND DISCUSSION
The total number of papers presented increase in average with 40 per year. This comes down to an increase of approximately 50 to 60 papers presented per year except for 1995 where the number of papers presented suddenly went down with 25. In contrast to the papers normally presented at the annual conferences of SRA Europe the papers in 1995 were longer and more detailed. In general, the field of risk analysis enjoys a continuously increase of interest. The total growth in the number of paper presented is based on growth within all risk topics.

Figure 1. Number of papers presented at SRA-Europe conferences distributed on topics. See text for detailed description of the risk topics. ncp = no classification possible.

In the early period of the current decade, a relatively large number of papers on industrial risk and infrastructure/transport are presented, which are replaced by an increasing number of papers on environmental risk and nuclear risk from 1995 onwards. Especially in 1993 a large number of papers concerning industrial risk and infrastructure/transportation is presented. Also this conference was dedicated to technological aspects and the ten-year anniversary of the Seveso directive, whereas the other annual conferences of SRA Europe were dedicated to more general themes welcoming papers on any aspect of risk analysis. The growth in the number of papers on environmental risk analysis presented closely follows the rate of the total increase, except for the conference in 1995 where environmental risk analysis dominated the conference. Approximately 35% of the submitted papers were concerned with environmental risk analysis. Also the number of papers presented on nuclear risk is increasing. This increase might be connected with a large number of papers produced within the RISKPERCOM project. The RISKPERCOM project is concerned with perception and communication of nuclear risks and enjoys financial support from the European Union.

Papers presented on “new” risk topics are increasing, emphasising the multidisciplinary aspect of risk analysis. The most prominent topics in this respect are food risk, economic risk, medical health risk and animal health risk. The growth in food risk is often connected with
scandals of intoxicated food. The most prominent example in this respect was the “Mad Cow” disease (BSE). Risk in relation to the newly established and intensely growing industries, biotechnology and information technology, are grouped as independent topics. It was expected that these industries would be of interest to the risk analysts. Surprisingly the number of papers presented on these topics is still limited when compared with other topics.

![Graph showing relative number of papers presented at SRA-Europe conferences distributed on topics.](image)

Figure 2. The relative number of papers presented at SRA-Europe conferences distributed on topics. See text for detailed description of the risk topics. ncp = no classification possible.

Even though human toxicology is an essential part of many risk topics, only very few papers for the SRA-Europe annual conferences are dealing with this topic. In contrast, at the SRA annual meeting, mostly held in The United States of America, human toxicology is the most popular topic. To illustrate this contrast human toxicology has been kept as an individual topic within this analysis.

A relative increase can be seen in the growth of papers presented, which are not particularly connected with a specific topic (ncp). These papers are dealing with methodology or risk analysis in a broader sense. This indicates that risk analysis is becoming a stand alone field of study. Also the total number of papers submitted confirms this development.

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RISK ASSESSMENT REVISITED: A REVIEW OF CONTAMINATED LAND RISK ASSESSMENT USING DATA FROM KNOWN CONTAMINATED SITES IN PORTSMOUTH, UK

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ABSTRACT
When contaminated land first became an issue in the early 1970's very little was known about the potential risks posed to human health or the environment. Since then, the developments made in this field have been considerable. This paper provides an historical profile of contaminated land risk assessment, beginning with a review of the initial methods used to identify and assess potentially contaminated sites. The paper then examines the use and applicability of specific risk assessment processes and computer software, concluding with a discussion on the future direction of the risk assessment process.

INTRODUCTION
Considerable developments have been made in the field of contaminated land risk assessment during the short time-scale over which the changes have occurred. As a subject contaminated land is relatively new, the problems associated with such land only being identified in the early 1970's following the detection of a number of heavily contaminated sites (Petts et al., 1997). At this time very little was known about the risks posed to human health or the environment from contamination, although this situation changed rapidly during the 1980's. However, the social and visual impacts of such areas, which were often left unused or derelict, were all too apparent. Indeed, measures introduced to regenerate such sites in the UK highlighted many more contaminated areas (Wallwork, 1974).

Since then many thousands of contaminated sites have been discovered, investigated and remediated, with the problems associated with contamination widely documented (Mather, 1993). Simultaneous advances in analytical techniques and the widespread availability of sophisticated computers have led to a greater understanding of the predominantly site-specific nature of contamination. The methods used to assess the risks associated with contamination are, however, still subject to debate (Petts et al., 1997).

This paper summarises the progress made in the field of contaminated land risk assessment, focusing initially on the changes that have taken place in the identification and assessment of such land. The paper also examines the current move towards risk-based assessments and further discusses the future of this technique.

IDENTIFYING CONTAMINATED LAND
When the contaminated land issue was first raised in the early 1970's, very little was known about the cause of the contamination, or the impact that it would have on human health or the environment. At this time the identification of such sites was often accidental, as seen in the notorious Love Canal incident in America where investigations were triggered by reports of...
ill health and the subsequent detection of chemical contaminants in flooded basements (Smith, 1991). However, as more contaminated sites were found and experience gained, specific methods of identifying such sites began to develop. One method is explained in figure 1.

Figure 1: Map Showing In-filled Areas in Portsmouth, UK.

By the early 1980's many industrial countries had become concerned about the problems associated with contaminated land, with a few creating their own legislative frameworks to deal with the contamination (Beaulieu, 1998). In Britain, the government exercised caution, and chose instead to publish only 'guidance' on this issue (ICRCL, 1987). Although different, the national approaches taken did have the same aim: - to reduce/remove the possibility of harm being caused to human health or the environment by the hazards associated with contaminated land (DOE, 1994).

Reducing or removing the potential for harm to occur requires the collection of a vast amount of data pertaining to every aspect of the site under examination. This 'need' has led to the creation of a structured approach to site investigation (BSI, 1981). Data collected using this procedure is then used to systematically assess the nature and extent of any contamination present.

SITE ASSESSMENT AND THE USE OF GUIDELINES
Initial assessments of potentially contaminated sites were rather basic. With no guidelines or data on what constitutes a significant hazard available, early assessments of contaminated land relied exclusively on the knowledge and experience of the individual assessor. The inadequacies of this method were soon realised, and guidance on assessing contaminated land was subsequently introduced (CARACAS, 1998). In Britain, the published guidance, ICRCL 1987, aimed at providing a 'systematic approach' to assessing the contamination status of individual sites.

Although including information on many of the practical aspects of redeveloping contaminated land, the main focus of this government guidance document was how to identify and assess the principal hazards. Of most significance was the introduction of the concept of trigger concentrations, specific concentrations of substances below which a site could be
classified as uncontaminated. Similar guideline and soil screening values were introduced in both the Netherlands (fig 2) and the USA.

Figure 2: Structure of Guideline Values

<table>
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<th>UK</th>
<th>Contaminant</th>
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<td></td>
<td></td>
<td></td>
<td>1-6</td>
<td>Threshold and Action</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dutch</th>
<th>Component</th>
<th>Concentration</th>
<th>Soil (mg/kg dry matter)</th>
<th>Groundwater µg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A*</td>
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</table>

Some time after the introduction of these guidelines, problems relating to their practical application became apparent. Many criticisms focussed on the very narrow range of substances included in the UK guidance tables, the failure to highlight the effect of bioavailability and mobility of contaminants causing further concern (CARACAS, 1998). As a result, many professionals began to conduct much more site-specific assessments aimed at assessing the risks associated with contamination.

RISK-BASED ASSESSMENTS
The most widely accepted method of assessing the risks associated with contamination focuses on the association between any contamination (source) and the effect that it may have on human health or the environment (target), known as the Source-Pathway-Target relationship (fig.2). This states that for a risk to occur, a pathway must exist between the source of the hazard and the target (O’Brien, 1998). Many of the models used to quantify the risks associated with contamination are based on this concept (Covello & Merkhofer, 1993).

Figure 3: Diagram Showing the Source-Pathway-Target Relationship

TECHNOLOGICAL ADVANCES
Since the early 1980’s, the increasing use of computers for data and word processing has led to the development of numerous risk assessment software packages. Over the past 5 years, many packages including Risk*Assistant, EMAGIS, Risc, and Risc Human have been developed specifically for the assessment of the risks associated with contaminated land.

The usefulness and applicability of this software has been investigated using data from a known contaminated site in Portsmouth, UK (Plunkett et al, 1998). This research has shown
both the advantages and disadvantages of using risk assessment software, as well as highlighting the overall benefits of a site-specific approach to contaminated land assessment.

However, a comparison of the results obtained from the assessment of the site using software, and those taken from the site investigation report completed in the early 1990’s, has served to show just how fast the field of risk assessment is continuing to change.

CONCLUSION
This review of the contaminated land risk assessment has shown some of the changes that have occurred since the issue was first raised in the 1970’s. It is, however, difficult to predict the changes will take place over the next 20 years, but undoubtedly this will involve a great deal more research and perhaps the development of a fully quantitative method of assessing risk.

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CONSIDERING 'ENVIRONMENTAL HARM':
QUALITATIVE AND SEMI-QUANTITATIVE TREATMENTS FOR
STRATEGIC RISK ASSESSMENT

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ABSTRACT
A central problem for risk assessors and managers is the characterisation of risk, and more specifically, the expression of risk significance. Conventionally, environmental risk has been characterised by reference to environmental quality standards that act as surrogates for presumed 'harm'. Such standards focus on the magnitude of impact and do not easily capture harm attributes such as irreversibility, or latency of onset. At a strategic level, comparisons of harm from hazards of wide ranging characteristics becomes complex, but is nevertheless essential for prioritising regulatory effort. We present for discussion, some recent research and development work undertaken for the benefit of informing our own strategic risk assessments. Semi-quantitative and qualitative methodologies under development are presented and their applications discussed.

Introduction

The conventional approach to considering detriment to the environment (from chemical releases, for example) has been through the comparison of environmental concentrations with an environmental quality standard. In general, the adoption of standards has served regulators well at the site specific level, in so far as they provides clear objectives for industry and other regulated groups as to what environmental levels are considered acceptable for various uses in different environmental media. A recent review, conducted by the Royal Commission on Environmental Pollution1, has commented on how standards are used and derived. At the strategic level, however, where data are often either sparse, or conversely, too voluminous, 'coarser' assessments are more often required to inform strategic decisions and prioritise regulatory effort. These strategic studies often rely on an informed view of the broader characteristics of harm (or potential harm) posed by the hazard(s) under study and usually centre on a consideration of observable impacts.

The Environment Agency of England and Wales (hereafter, the Agency) is one of Europe's largest regulatory bodies with regulatory and supervisory powers across the areas of environmental protection, water resources and flood defence, recreation, navigation and conservation. Beyond its 'front-line' regulatory work, the Agency is involved in setting environmental priorities at the area, regional and national level and in developing long-term strategies for its activities, by reference to the goal of sustainable development. This type of strategic work needs ways by which observable or potential impacts from a variety of existing or future hazards can be compared alongside one another in order to inform corporate planning and resource decisions. This is a complex activity and tools in use are often 'broad brush' and focus on a 'Boston Box'2 approach or versions of it, sometimes formalised into ranking systems. Two strategic risk assessment (SRA) tools currently being developed by the Agency to consider environmental harm are briefly presented below.

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Developments on structured approaches to considering ‘environmental harm’

**Semi-quantitative tool.** Initial work has been focussed on providing a ranking tool for environmental impacts from different sources that could then be tested on data derived at local, regional and national levels. The objective was to bring the tool to a proof of concept stage. In broad terms, development of this tool has focussed on:

- assessing whether it was possible to identify key relationships that could be used to map different environmental impacts from a range of human and natural activities by reference to the characteristics of environmental harm; and
- evaluating whether these relationships could be normalised to allow a comparison of environmental impact through the use of a simple ranking system.

Following an initial feasibility study, a model was structured using ‘look up’ tables, populated with elicited criteria for what were regarded as the key attributes of harm:

(a) the potential scale of the effect (H); ranging, for chemical contamination, from ‘presence without overt effect’ (low) to effects at the community level with ‘long-term irreversible effects’ (severe);

(b) the potential status of the receptor (R); sensitivity in terms of local, national or international designation; and

(c) the persistence of the hazard (acute to chronic relative to receptor life-time; T1) and reversibility of impact with respect to each receptor and/or media (readily to irreversible; T2)

The indices are ranked and scored using the above criteria and the scores shown in Table 1 with the shaded areas indicating areas of unacceptable harm. A spreadsheet was then used to compute a normalised ‘harm index’ for each hazard-receptor combination, by estimating ‘harm’ as: \(\sqrt{H^2 + R^2 + (T1 + T2)^2}\).

**Table 1: Severity matrix for the semi-quantitative ranking of environmental harm**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Severity rank (and scores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale of Effect (H)</td>
<td>Low (1)</td>
</tr>
<tr>
<td>Status of Receptor (R)</td>
<td>Low (1)</td>
</tr>
<tr>
<td>Persistence in Media (T1)</td>
<td>Acute (1)</td>
</tr>
<tr>
<td>Reversibility (T2)</td>
<td>Readily reversible (1)</td>
</tr>
</tbody>
</table>

The tool was piloted for applicability at a local and national scale by using data from the River Teign Local Environment Agency Plan (LEAPs are catchment-based local environmental strategies) and from the Agency’s “State of the Freshwater Environment Report” (which provides a national, strategic overview). These pilot studies showed that the issues identified by the SRA tool were generally similar to those identified by other approaches. The tool also provided a scaled ranking of the issues and allowed meaningful comparisons and the prioritisation across a range of geographical scales (e.g. between and within regions). A structured approach offers the prospect of a framework for improved objective setting, prioritisation and monitoring, although as with all such ranking schemes, it is important to ensure that the numerical scores are not overrated.

**A qualitative approach to considering socioeconomic aspects.** Ranking tools such as those discussed above inevitably raise issues of weighting and the values ascribed to the various attributes. Formalisation of these issues is always a complex matter. The level of information
available on the social and economic impacts of environmental damage is often sparse and its
collation and presentation can be contentious. As a consequence, a qualitative (rather than
semi-quantitative) approach is now being considered to integrate these aspects.

In concept, the approach involves capturing the key characteristics of environmental harm
(magnitude, reversibility, spatial and temporal extent, latency etc.), using key words, or
‘attributes’ with meaning in a technical and socioeconomic context. In the first instance, a
number of candidate interpretations from the literature were reviewed with the objective of
developing a view on the value of the different approaches considered. An initial set of
attributes were developed and tested on a local case study for initial applicability. This
information was presented and discussed at a workshop to obtain feedback from a wider
audience of Agency colleagues and external experts actively involved in this field. In
considering the attributes of harm, it was assumed for simplicity that the “source-pathway-
receptor” relationship was already established and that realisation of the hazard results in
some degree of damage. Without prioritisation, a total of 22 potential attributes of harm were
initially identified. For each attribute a description, a qualitative scale and examples were
provided. Examples of these attributes, together with the proposed scales are presented in
Table 2.

Table 2: Examples of attributes of harm identified in the initial framework

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Scale</th>
<th>Low</th>
<th>Intermediate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial</td>
<td>Point source</td>
<td>Local</td>
<td>Regional</td>
<td>National</td>
</tr>
<tr>
<td>Reversibility</td>
<td>Reversible in short period</td>
<td>Reversible in weeks</td>
<td>Reversible in years</td>
<td>Reversible in decades</td>
</tr>
<tr>
<td>Dread</td>
<td>None</td>
<td>Specific individuals affected</td>
<td>Reversible in years</td>
<td>Groups of individuals affected</td>
</tr>
<tr>
<td>Mitigation potential</td>
<td>Not required</td>
<td>Controllable by simple management procedures</td>
<td></td>
<td>Controllable by complex and active management</td>
</tr>
</tbody>
</table>

The workshop concluded the following:
(a) The complexity of the task can be overwhelming, but the need was for a straightforward
framework that could be easily applied by non-experts in environmental risk, albeit with
some expert assistance;
(b) The issue of agreed definitions is recurrent. There is considerable potential for conflicting
and overlapping meanings especially when incorporating multidisciplinary inputs;
(c) A central challenge is the context-specific nature of individual impacts, which makes the
selection of a ‘core set’ of attributes, and meaningful comparison between impacts
difficult – case studies can assist;
(d) In general, the approach was thought to be useful within a regulatory context, but needs
refining and requires testing on a number of “real” case studies. Often, statute has
specific definitions of what constitutes environmental harm that may over-ride a general
treatment;
(e) Further consideration needs to be given on how to handle uncertainty;
(f) It may not be helpful to force distinct technical, social and economic interpretations on the
various attributes. For example, the magnitude of an environmental impact can be
described in technical, social and economic terms – a more holistic treatment is sought, but can very difficult in practice to operationalise;

With reference to the latter point, two sub-lists can be recognised -
(a) those attributes that describe the nature of the harm, i.e. which may be used to indicate the extent to which an activity, event or process is harmful; and
(b) those attributes that describe the values we place on the nature of the harm.

One way of integrating and thus, operationalising the various attributes may be to consider them graphically, by plotting the attributes that describe the nature of the harm on the vertical axis and the attributes describing stakeholder reactions to ‘harm’ (i.e. how we feel) on the horizontal axis (Figure 1). Figure 1 also provides examples of individual attributes that might fall under these categories. Each of the attributes is scored on a qualitative scale (as shown in Table 2) so that attributes that have been plotted it the shaded area of Figure 1 will cause the highest overall impact in terms of the nature of the harm or the perception of that harm. This sort of approach can be used in decision-making to target the impacts that are causing the greatest concern.

**Figure 1:** Graphical representation and examples of attributes

<table>
<thead>
<tr>
<th>Nature of the harm</th>
<th>Human responses to harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal extent</td>
<td>Mobilisation potential</td>
</tr>
<tr>
<td>Spatial extent</td>
<td>Uniqueness</td>
</tr>
<tr>
<td>Stock at risk</td>
<td>Tolerability</td>
</tr>
<tr>
<td>Severity</td>
<td>Dread</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Imposition</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**
The approaches developed have value as coarse screening tools allowing the assessment of various issues at a strategic level. They also allow for a common understanding of environmental harm, highlight its multivariate nature and enable comparability across different effects and different sources. There is value in developing a structured approach, but it is recognised that its viability, how to adopt it and when it would be appropriate to use such a framework need to be clarified further.

**ACKNOWLEDGEMENTS**
The authors wish to thank the Environment Agency for permission to present this work and colleagues in the National Centre who contributed to its development. They also wish to acknowledge the combined efforts of the expert participants to the Agency’s Workshop on Environmental Harm, held at Heythrop Park, Oxfordshire, 29 June-1st July 1999.

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2. a widely used 2d prioritisation matrix of impact and likelihood


TEACHING ENVIRONMENTAL HEALTH RISK ASSESSMENT IN EUROPE: A SURVEY AMONG MEMBERS OF SRA-EUROPE

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The rising concern among residents of developed countries over health risks linked to environmental exposures is one factor in the American National Academy of Sciences' 1983 effort to formalise risk assessment procedures. This formalisation has served as a basis for a number of national regulatory systems, European Directives or guidelines for researchers, experts and practitioners.

It therefore appears useful and justified to conduct a survey among the members of the Society for Risk Analysis-Europe (SRA-E) to identify teaching and training opportunities in the area of environmental health risk assessment, and their content and methods. The study is conceived of as serving those members involved in this area of teaching and training, and providing a basis for networking and exchange. Another aim of the study is to identify converging or conflicting semantic, conceptual and methodological currents, in the interest not of standardising approaches, but of facilitating communication among researchers and practitioners. Justifying this concern is the example of diverging vocabularies seen between environmental health experts and practitioners who remain close to NAS terms, and, professionals in the food safety sector who appear to be developing their own set of terms.

The results of a questionnaire survey are presented. Proposals are made (and received) for organising debate and information exchange within SRA-E on the issues examined.
TRACK 2
SESSION 3

NEW RISKS
SESSION 3

NEW RISKS

The rising concern among residents of developed countries over health risks linked to environmental exposures is not unique to the American National Academy of Sciences' 1982 effort to delineate risk assessment procedures. This growing concern has served as a basis for a number of antitoxic regulatory systems, European Directives or guidelines for researchers, experts and practitioners.

It therefore appears timely to assess the current perception of the members of the Society for Risk Analysis (SRA) of potential trends in developing methodologies and their existing and available. This study is concerned with assessing those missions involved in the area of teaching and learning, providing a basis for networking and exchange. Another aim of the study is to identify emerging or emerging issues, methodological and methodological sources, in the literature not all standardizing on the use of standardizing the concept of emerging standardization, and between environmental health experts and professionals who could serve as NAS' authors, and professionals as the basic safety and their efforts in developing their next set of terms.

The results of an questionnaire survey of a large number of questions are made (and answered) for organizational and institutional exchange within SRA and on the issues examined.
CROSS-BORDER RAIL TRANSPORT AND THE RISKS LINKED TO CULTURAL DIFFERENCES.

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ABSTRACT
Railway companies are facing new issues in safety and reliability with recent significant increases in passenger and freight traffic. This European opening of networks may lead to an increase in risks of accidents, due to the cross-border characteristic. We define the plural concept of border as the limit between two different environments: geographic, linguistic, technological or cultural. Consequently, we can consider the necessary management of cultural differences between operators from different networks and the impact they can have on behaviours, decisions and actions.

We cite authors such as Schein (1990), Weick (1987), (1993), Ouchi (1980), Pidgeon (1998), Hofstede (1991) to explore how culture is integrated in organizations theory. Finally, we present a questionnaire to explore the hypothesised link between culture and behaviour. It will be used to survey on-board staff (drivers and train managers) and other operators working at the interface.

I/ The context and the hypothesis
In the aim of improving safety and reliability of transport activities, railway companies have to face new issues, given the latest evolutions of traffic. In the past few years, cross-border transport has significantly increased, not only on Eurostar or Thalys, but also in freight. Consequently, we assume that this European opening of networks leads to an increase in risks of accidents, due to the cross-border characteristic. This point seems obvious, because it is theoretically justified by the augmentation of system complexity.

However, it is necessary to wonder whether or not this hypothesis is confirmed by daily work reality. If not, this doesn't mean that the hypothesis is false, but rather that we have to seek and identify both adjustment variables which appear in the process and regulating mechanisms implemented by the operators in their daily working practices. Indeed, they are going to try to compensate spontaneously the effects of new situations, to adjust themselves to a change, to a new environment, and most of the time, they do so with efficiency. These questions are linked to the ability to quickly react in case of something unplanned occur. In our cross-border context, it is particularly relevant because drivers and train agents from a given infrastructure could be in a foreign environment when an emergency case happens and in these conditions, what are their landmarks, their references? We can wonder on the one hand, what the team performance becomes when operators are not in a usual work context anymore, and on the other hand, what the efficiency of the cooperation between teams from different networks is. Consequently, new risks appear linked to misunderstandings, different expectations, different anticipations among operators, and this alters the adjustment variables and the regulating mechanisms they can usually implement.
However, some other limits to this adjustment ability may exist: they depend on cognitive factors and physical factors (fatigue, increase in the working mental load, stress...). For these reasons, it is important to try to understand what operators normally do, in order to find an explanation and to identify some behaviour influencing factors.

In this objective, our analysis framework leads us to the necessary management of cultural differences between operators from different networks and the impact they can have on behaviours, decisions and actions. It seems obvious that technical rationality and functional management are not sufficient to explain what happens in organizations because the apparent same technical environment due to railways leads people to act differently. Safety practices, or more generally working practices, are also determined by cultural factors. Consequently, this analysis needs to take into account other concepts which belong to a rationality linked to the context, less formal and more uncertain.

These considerations given, we formulate our main hypothesis assuming a link between operators' culture and their way of behaving.

II/ Organizational culture

From the theoretical point of view, we consider the cultural approach in organisations theory. We refer to Schein's famous definition of culture (1990, in American Psychologist): 

Culture can be defined as a pattern of basic assumptions, invented, discovered, or developed by a given group, as it learns to cope with its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore is to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.

He thus distinguishes three levels at which culture manifests itself: observable artifacts (technology, written and spoken language, physical space organization, clothing habits), values (describing the way of acting, speaking and thinking inside an organization), and basic underlying assumptions (presuppositions, basic orientations, creeds). This last level enables us to interpret perceptions, behaviours, judgements, decisions taken by the operators inside the organization.

In the context of cross-border transport, the objective of identifying internal and external factors which influence the system management leads us to define the way we will consider some concepts.

When a train crosses a border, different consequences on operators can appear depending on the field of the analysis. Indeed, work activities are influenced by a change of environment due to the border, but in relation with the kind of border we consider, or more precisely with the kind of environment. In our analysis, the concept of border is the limit between two different environments, and by environment, we mean geographic, linguistic, technological on the one hand, and cultural on the other hand.

In cross-border transport, the fact that trains go from a railway infrastructure to another leads us to study more particularly the impact of these cultural juxtaposition on operators and on their performance in daily work practices. For these reasons, we will focus on the concept of culture.

For this purpose, as Schein, we distinguish different dimensions but which rather depend on the kind of culture they rely on. We mean that the operator is under the influence of his own culture (individual), of his professional culture (team), of the organizational culture (firm), and of a national culture (country). Given this understanding of the concept, a question can be
asked: how can the operator integrate these levels? all with the same intensity? Which one prevails?

III/ The methodology

We use a methodology developed in research on group behaviour (SYMLOG; Bales & Cohen, 1979) adapted by Poumadère (1985) in order to identify the values the individuals and the groups associated with specific organizational stakes. Studies have already been done by Poumadère, (1988) on the management of European branches of an industrial vehicles firm, and by Mays and Poumadère (1989) on safety practices in French nuclear power plants. The authors assume that "safety performance is an outcome of interactions between technical and organizational factors". But traditional risk analyses are not designed to take into account this kind of factor. Hence, the need for new methods in order to consider values systems, social representations, that is to say cultural factors.

In Poumadère’s approach using SYMLOG, individual and organizational values on three relevant themes - daily attitudes, safety practices, cooperation - are measured in a three-dimensional factor space. The same questionnaire is submitted to different groups; an action-research design then calls on the participants to analyse their own and system-wide results in a team setting. These feedback sessions are an important feature of the method; the given population is involved in discussions and interactive elaboration of data.

Given our multicultural context, our main concern will be to demonstrate how cultural factors can intervene in the management process and can lead to specific risks because of the gaps between two cultural units. Note that according to our definition of culture, these units can be two individuals, two different job specialities, two different organizations, or two different countries. Consequently, as Poumadère and al. had implemented the SYMLOG methodology to identify the safety practices influencing factors, we will use the same instruments to understand how human and organisational factors in this multicultural context can have a significant role in transport safety. This kind of study is particularly relevant because given the economic context, French railways want to develop more and more cooperation between European countries (freight and passenger transport).

In the context of doctoral research performed in part with an internship at the French national railway (SNCF), we adapt the approach to our own population and implement it in a sequential way.

First, we have to verify if some risks, incidents or accidents are really linked to the multicultural variable, through expert interviews and study of events reports. If they are, we’ll try to identify errors and misunderstandings at the origin of the event. If they aren't, we must analyse the regulating mechanisms implemented by operators, teams and/or the organization in an implicit and informal way but capable of counterbalancing the new risks. For this, we have chosen a population made up not only of on-board staff (drivers and train managers), who actually cross the border, but also of sedentary agents who are working at the interface.

Then, we plan to use the SYMLOG questionnaire to explore the assumed link between culture and behaviour in the context studied. Three main topics are to be submitted to the given population (both sedentary staff and train agents). In this work context, it seemed particularly relevant first to question people about the attitudes they may develop in their daily work tasks, then to study the emergence of the cooperation within teams, and finally, how operators perceive safety rules. The themes chosen for evaluation across the SYMLOG values inventory are: 1/ Safety and risk perception, 2/ Interpretation of rules by operators, 3/ Cooperation and communication between teams. The answers to these questions could reveal operators' characteristics, the shared values and representations of the system, that is to say what makes
up the culture, because these fields square with the levels of culture we identified on the theoretical level.

The methodology provides a stable questionnaire whoever the population may be. Consequently, this feature enables us to make comparisons between different populations. This is very useful in a multicultural context, because thanks to that, we can compare cultural factors between two, or more, different units. We will submit the questionnaire to a French population (on-board and sedentary agents) and to foreign operators (Italian, German and English people). Our hope is to identify discrepancies between values developed by operators from different infrastructures. This result could validate our hypothesis according which people may behave in a different way because of different backgrounds (professional, organizational, national).

The questionnaire will be submitted in October 1999, the analysis will follow.

References


MODELLING ERRORS OF COMMISSION: APPLICABILITY OF ATHEANA IN THE CHEMICAL INDUSTRY

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ABSTRACT
The ATHEANA technique has been developed in the nuclear industry in the USA to assist risk analysts to incorporate errors of commission in their analysis. The strengths and weaknesses and the applicability of the technique to errors of commission in chemical accidents were studied in a project sponsored by two Dutch Ministries. The paper discusses definitions, the linking of the ATHEANA technique to QRA and a number of possible improvements of the technique to make it useful in the process industry.

1. ATHEANA: FROM NUCLEAR TO CHEMICAL CONTEXT
The ATHEANA technique (A Technique for Human Event ANAlysis- NUREG 1624 [1998], NUREG/CR 6265 [1995]) was developed in the US nuclear industry largely to tackle the problem of predicting and quantifying errors of commission during failure events. It consists of a procedure and set of supporting tools and guidance for identifying events sequences of significance to plant integrity in which operators may “inappropriately disable operating safety equipment or fail to actuate necessary equipment”. The following steps identify the “error forcing contexts” (EFC) which can mislead the operators into these unsafe acts, screen them for their effect on the PRA model, quantify them by estimating the frequency of the EFCs and the probability of the human failure events (HFEs), and integrate them into the PRA.

This technique potentially fills a gap in the risk analysis spectrum and is therefore of more general interest, also outside the nuclear industry. A short study, sponsored by the Dutch Ministries of the Environment and of Social Affairs and Employment, was conducted to assess the applicability of the technique to chemical process accidents and to evaluate its strengths and weaknesses. The study involved analysis of a past major chemical accident with the technique to see how well it could unravel the errors involved in it.

1.1. Definitions
We found the ATHEANA definitions of errors of commission (EOCs) too vague, as has been much of the discussion overall on this topic (see also Dougherty 1998). We have defined them as follows, dropping the term “overt unsafe” from the ATHEANA definition:

An action that leads to a change in plant configuration with the consequence of a degraded plant state. It may arise from: either an error of recognition, diagnosis or intention, that leads to a series of acts formed with well-meaning intentions, but which are inappropriate for the technical scenarios that pertains; or an isolated error introduced with an otherwise appropriate series of actions that may arise from a random aberration in behaviour, or may be induced by the inappropriate application of a habitual task behaviour.

The underlying psychological mechanisms of the intentional and unintentional EOCs are different, as are the EFCs which favour them, but all of them are actions regarded as legitimate by the person making them at the time.
An error-forcing context (EFC) is:

The combined effect of performance shaping factors and plant conditions that trigger psychological error mechanisms, and which must address not only the initial error but also the failure to recover it.

The latter definition emphasises that EOCs are processes. The initial error, especially if it results from an intentional response to a situation, resulting e.g. from a misdiagnosis, leads to persistent behaviour which usually has to be actively challenged by the system response before it is broken off, and may not be even then. We regard the absence of these challenges and the omission of such checks as part of the EOC and not as errors of omission. EFCs are characterised by the plant behaviour being outside the expected range, and/or not understood, by evidence of the plant state/behaviour not being recognised, and by prepared plans being inapplicable. The tools provided by the technique need to trigger discovery of these “non-nominal accident conditions” and to provide help in understanding the plant conditions and performance shaping factors which can lead to the inappropriate response of the operators.

1.2. Link to the QRA

We expanded the ATHEANA definition to distinguish six types of EOC in terms of their relationship with the QRA:

1. A human action which is an initiator. It directly causes a dynamic change which initiates the accident sequence.
2. A human action which defeats a safety system during the post-initiator sequence.
3. A human action in the post-initiator sequence which makes the situation worse (e.g. accelerates the dynamic change).
4. A human action which defeats a safety system at some time before it is needed (before the initiating event).
5. A human action which defeats the information system at the same time as it is needed (such as switching off an alarm during the post-initiator period).
6. A human action which defeats the information system before it is used (such as making errors in a written procedure, wrongly calibrating an instrument).

The major difference with the nuclear application is that we include the period prior to the initiating event in the analysis. This is necessary, since the dynamics of chemical processes are very different to those of nuclear processes and post-initiator intervention of operators is often of minor importance. This can also be seen as moving the initiating event back in time. For example, in the accident analysed in this project we considered the writing out of the wrong recipe for a chemical batch as the initiator in a sequence which finally led to a runaway reaction a day later.

In modelling the EFCs we also expanded the ATHEANA approach to give more emphasis to the consideration of failure modes related to design and to link the analysis much more explicitly to the management system, in which EOCs may also be located. We modelled EFCs as having three possible types of outcome for the QRA:

1. **Increasing probabilities** or frequencies of occurrence of initiating events and/or base events in the existing fault trees. This may increase the top event probability. EOC types 1, 5 and 6 can do this.
2. Adding **new scenarios** with an additional event tree to the set of already existing scenarios, providing more routes to a Loss of Containment. EOCs 1 and 3 can do this. This would be a very interesting outcome as new scenarios broaden the perspective of the
QRA, but only proactive testing of ATHEANA can indicate whether it really can discover these. Our study was only retrospective, of an accident already occurred.

3. The EOC introduces couplings between basic events in the fault trees, initiating events, and safety system failures in the event trees. Almost all EOC types can do this. The result should be modelled through dependent failures which can drastically increase the probability of an LOC. This is difficult to model in QRA, and Management Factoring approaches address this problem (Oh et al. 1999)

1.3. Modelling.
The implication of expanding the analysis to pre-initiator events is that we will not have the well-defined post-initiator event trees of the original ATHEANA method to anchor the search for HFEs and EFCs. We have sought to replace this basis for modelling with a task step representation linked to process procedures. In the runaway accident analysed in this project, these were the tasks of choosing and mixing the recipe, filling the tank and processing the batch (heating, subsequent cooling and stirring), with their associated checks. Tabular task analysis (TTA) methods are appropriate for such modelling. At each step we identified the “lines of defence” (LODs) which keep the process within a safe “space-state”. For the recipe step these include a competent person available when needed to choose or write the recipe, accurate copying from a reliable source, producing a well specified, legible recipe, available at the place needed (the raw materials tanks), and checks to detect and correct slips and mistakes. These lines of defence can be linked generically to the eight critical resources and criteria for safe operation identified in the I-Risk project (Oh et al. 1999), providing an explicit link to the safety management system. The ATHEANA tools can then be used to interrogate the ways in which the lines of defence can be defeated or circumvented by the EOCs, and can explore the EFCs which may lead to the operators regarding these actions as legitimate.

The proposed approach has even more resemblances than the original ATHEANA method to the HAZOP technique which is thoroughly embedded into the culture of risk analysis in the chemical industry. It extends the principle to human error analysis, requiring only a new set of parameter and guide words. It is likely that the teams already trained to use HAZOP could therefore conduct the additional analyses with extra training to understand the link between human error and its context – EFCs.

2. STRENGTHS AND WEAKNESSES

(-) Poorly defined central concept (EOC)

We had to come up with some tighter definitions for EOC (see above).

(+/-) The method offers a relatively complete toolbox but is complicated for risk assessment analysts who are inexperienced in its use

NUREG-1624 provides copious support for each of the stages of the analysis. The very bulk of that report (pp300+) indicates that very considerable support is necessary. This locates ATHEANA as a tool only suitable for use by experts after considerable training in human factors. For chemical applications pre-initiator actions must be analysed. For this new representations, as proposed above, are needed as a basis to work on (TTA + LODs)

(+ ) Good central concepts + new mindset: EFCs (Plant conditions and PSFs), Error mechanisms.

The overall concepts cover more of the important aspects in accident causation than previously by bringing together the whole human-technical system and their interactions under the eye of the analyst. Particularly important in this respect is Error Forcing Context
which analysts have previously not considered. Retrospective analysis of the runaway accident used in this study gave a new perspective to examining the causes of the accident and gave rise to questions not previously considered. Previous HRA techniques have tended to be overly human-centred, ignoring the whole socio-technical system. Technical aspects of chemical plants significantly affect the task of the human operator in safe control and the way a plant is organised. Organisational factors also condition human tasks and errors (Bellamy et al 1995). ATHEANA is rather weak on the organisational and management aspects, but the EFC could be extended to include them.

PRIORITISATION SYSTEM (FOR HOMING IN ON THE MOST IMPORTANT AREAS/HIGHEST RISKS) IS BECOMING AVAILABLE, BUT STOP RULES ARE STILL UNCLEAR

The application of ATHEANA to even just a small part of an installation could be a lifetime’s work. The number of potential EFCs and EOCs is always large and probably only limited by creative imagination and what is seen as credible. NUREG 1624 suggests giving priority to unrecoverable errors relating to initiators and essential plant functions for responding to them. Further support is given in terms of problems from incident analysis (LERs), which have been found to occur relatively frequently. It is clear, however, that such support is very dependent on good analysis of a suitable incident database – something not available for chemical plants.

REQUIRES EXTENSIVE TECHNICAL KNOWLEDGE OF THE BEHAVIOUR OF THE TECHNICAL SYSTEM TO BE ABLE TO CONSIDER PLANT CONDITIONS IN THE ERROR FORCING CONTEXT

In particular the problem arises with new scenarios, not previously considered. In the runaway accident we analysed, one of the reasons for the EOCs was the lack of knowledge at the time of how certain chemical mixtures behaved. A wrong mix led to previously unknown effects. Whilst “wrong recipe” as EOC should be identified by the (modified) technique, the question is whether analysts would consider this particular wrong mixture and think its occurrence credible enough (proactively) to initiate a study of its behaviour if made, and hence discover the inadequacy of the plant design to handle it. In the chemical context at least, the knowledge of plant and process behaviour will have to be very good to be able to really come up with the plant and process behaviour which an operator could be faced with. The method needs to specify the requirements/expertise for team members in carrying out the different steps in the process.

POSSIBLE BASIS FOR DISCUSSION WITH MANAGEMENT

Finally we regard ATHEANA at least potentially as a good tool for generating discussion and improvement, if a system for formal follow-up of identified risks is added.

REFERENCES


Oil and gas operations present a very complex problem to a risk manager. In such a complex environment, a structured approach to risk assessment is necessary in order to prioritise and rank potential improvements for more detailed analysis, and to make sure that all the risks are receiving the attention they deserve. We present an ordered framework that uses risk assessment at the right time, and in the right level of detail, to achieve a fit-to-purpose analysis.

The tricky relationship between risk-reducing factors and the level of residual risk which is carried by a site is discussed, and a Bayesian method for modelling reality is introduced. This approach is consistent with the latest European regulations for site licensing.
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...
1. INTRODUCTION: CRITERIA FOR RISK EVALUATION

Risk evaluation involves assessing the potential impact and likelihood of adverse outcomes. This includes identifying the severity of potential consequences and the probability of occurrence. Risk management strategies often consider these criteria to prioritize actions and allocate resources appropriately.

2. RISK MANAGEMENT: SCIENCE-BASED, PRECAUTIONARY AND DISCUSCIVE STRATEGIES

Risk management strategies are designed to mitigate risks through various approaches. These include scientific assessments, precautionary measures, and discursive strategies. Each approach aims to provide a comprehensive framework for addressing risks in a systematic and transparent manner.
TRAC 2

SESSION 4

RISK MANAGEMENT

METHODS
1. INTRODUCTION: CRITERIA FOR RISK EVALUATION

Rational risk evaluation and management requires the interpretation of the technical, natural and social sciences (cf. Fiorino 1989). The central categories of risk evaluation are the *extent of damage* and the *probability of occurrence*. Damage is generally understood as the negative evaluated consequences of human activities (e.g. accidents by driving etc.) or events (e.g. volcanic eruptions etc.). In contrast to the measurement of damages, there does not exist an obvious method to validate the *probability of occurrence*. The term probability is used for events where information or even only presumptions about relative frequencies or subjective strength of beliefs are available, but where the precise time of occurrence remains uncertain.

We consider it useful to include further criteria of evaluation into the characterization of risks (Kates and Kasperon 1983; California Environmental Protection Agency 1994). These criteria are already used or proposed in several countries such as Denmark, Netherlands and Switzerland (cf. Löfstedt 1997; Hattis and Minkowitz 1997; Beroggi et al. 1997; Hauptmanns 1997; von Piechowski 1994). The following criteria are relevant:

- **Incertitude** (related to statistical uncertainty, indeterminacy, and ignorance);
- **Ubiquity** defines the geographic dispersion of potential damages (intrigenerational justice);
- **Persistency** defines the temporal extension of potential damages (intergenerational justice);
- **Reversibility** describes the possibility to restore the situation to the state before the damage occurred (possible restoration are e.g. reforestation and cleaning of water);
- **Delay effect** characterizes a long time of latency between the initial event and the actual impact of damage. The time of latency could be of physical, chemical or biological nature; and
- **Potential of mobilization** is understood as violation of individual, social or cultural interests and values generating social conflicts and psychological reactions by individuals or groups who feel inflicted by the risk consequences.

The question arises how societies should decide about fundamental procedures of evaluation and management concerning uncertain consequences of collective actions. We want to emphasize that scientifically based assessments for evaluating the consequences of decision options as well as precautionary approaches for being on the safe side if uncertainties are high, are both rational procedures of selection. Using science-based principles the evaluation focuses on the probability of occurrence and the extent of damage. This is advisable if there exists enough certainty to make reasonable assessments of the two criteria. Precautionary approaches should be preferred if, however, these two central criteria are characterized by high uncertainty.

2. RISK MANAGEMENT: SCIENCE-BASED, PRECAUTIONARY AND DISCURSIVE STRATEGIES

The essential aim of the risk evaluation is to characterize risks in order to construct effective and feasible management strategies, regulations and measures for the risk policy (WBGU
The characterization provides a knowledge base so that political decision makers are capable to decide which specific political strategies and measures are most appropriate. A comparative view on the risk management scheme (Table 1) indicates that we can distinguish three central categories of risk management, namely science-based, precautionary and discursive strategies. Risks belonging to the first category require mainly science-based management strategies, risks belonging to the second demand the application of the precautionary principle, and risks belonging to the third necessitate discursive strategies for consciousness and confidence building. This distinction does not mean that within each category the other strategies and instruments have no place, but they take a 'back seat'.

2.1 Science-Based Management Strategies

The risks belonging to this category can adequately be handled and managed on the basis of science-based strategies and regulations. Nuclear energy, large chemical facilities, dams, NBC-weapons and early warning systems, but also infection diseases are typical examples. In the case of nuclear energy, chemical facilities and dams the two most important criteria probability of occurrence and extent of damage are relatively well-known. The science-based assessment of uncertainties remain within reasonable boundaries of statistical confidence intervals. Therefore, the potential for negative outcomes need to be addressed. First, the potential of disasters must be reduced by research to develop technical and organizational substitutes. For example, in the past the primary strategy of nuclear energy was to reduce the probability of a core melt-down. This strategy was insufficient. More useful would have been a change towards reducing the catastrophic potential (meanwhile this seems to take place).

We also include in this category those risks where science-based and precautionary strategies need to be combined because the risk potentials are characterized by a good knowledge on the extent of damage, but larger uncertainty about the probabilities. To remedy this knowledge gap increased research and a thorough monitoring for better assessing the distribution of probabilities are required. Stricter rules of liability and compulsory insurance for those generating the risks would provide additional incentives for reducing the disaster potential and preventing unwelcome surprises. Operators of risk sources are encouraged to improve their knowledge and to reduce the remaining uncertainties.

Increasing resilience, i.e. the resistance and robustness against surprises, is an additional instrument for both science-based and precautionary regulations. Capacity building improves the institutional and organizational structures to cope with risks and guarantees control over procedures of licensing, monitoring and training etc. Additionally, technical procedures as redundancy, organizational security units, the integration of latitudes, buffers, elasticities and diversification, i.e. the local distribution of risk sources, are important steps to enhance resilience.

Last, not least emergency management should also be included. This strategy is not regarded as insignificant, however, a strategy of damage limitation should stay behind the primary rationale of reducing risk strategies.

2.2 Precautionary Management Strategies

Typical examples of this management category are the release of transgenie plants, specific applications of genetic engineering, the increasing greenhouse effect, persistent organic pollutants (POP) and endocrine disruptors. These risk potentials are characterized by a relatively high degree of uncertainty concerning the probability of occurrence and the extent of damage. As a result the assessment of these risks is connected with high uncertainty.
Therefore, the first priority of risk management must be to take precautionary measures. These measures range from the development of substitutes, over containment of application to institutional regulations such as ALARA ("as low as reasonably achievable"), BACT ("best available control technology"), technical standards etc. In addition, precaution requires wide-ranging research efforts that need adequate financial support.

The improvement of knowledge can provide a higher level of validity and certainty for future risk analysis. Research on how to ascertain the probability of occurrence and the extent of damage is needed. Additionally, international institutions for controlling, monitoring and safeguarding including an early warning system is necessary.

At the same time prevention strategies – in particular limiting the use of the risk sources in specific areas and spaces –, research efforts to develop substitutes, and regulatory measures to limit and reduce the risk sources are needed because the potential damages can reach transboundary or global dimensions. The risk potentials should be decreased by reducing dispersion, exposure or persistence. A radical option is also to prohibit them completely. Regulatory procedures should limit quantities through environmental standards or even more advisable by means of certificates. In some cases the use of strict liability is appropriate. Furthermore instruments of technical safety measures and capacity building complement the regulatory requirements.

2.3 Discursive Management Strategies

The third category requires discursive strategies because either the potential for wide-ranging damage is ignored, due to a delay effect as e.g. climate change, or – the opposite – harmless effects are perceived as threats as e.g. in the case of electromagnetic fields. These risks are not controversial due to the range of scientific uncertainty. In the case of climate change human beings tend to ignore the risks because of the delay between the initial event and the damage impact. Even if the probability of long climate change were less than one percent (which exceeds the most optimistic assessments), it is still several orders of magnitude higher then the risk of large-scale technologies such as nuclear power or dams. In the case of electromagnetic fields the probability of occurrence and the extent of damage are known among scientists, i.e. any effect is below any statistical significance level, though not zero. The hazardous nature of the risks is mainly based on the subjective perception that can lead to stress, anxiety and psychosomatic malfunctions.

Therefore these risks require strategies for building consciousness and confidence as well as strengthening trustworthiness in regulatory bodies and initiating collective efforts to set up institutions for dealing with issues that require long-term responsibility. The aim is to commit relevant actors to a Code of Conduct and to establish long-term international institutions (European and/or UN risk institutions) who have the mandate to strengthen the responsibility of the international community.

In order to provide people with the opportunity to learn about the comparative risk situation, they should be involved in decision making processes so that they are able to integrate the remaining uncertainties and ambiguities into the political deliberation. Is the mobilization potential high, confidence-building is essential in order to have the public involved in learning about the real extent of damage and the probability of occurrence. Independent institutions with high social esteem are important brokers for informing the public about the results of scientific research.
Table 1: Management Strategies

<table>
<thead>
<tr>
<th>Management</th>
<th>Extent of damage</th>
<th>Probability</th>
<th>Strategies for action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science-based</td>
<td>high</td>
<td>low or uncertain</td>
<td>reducing disaster potential; ascertaining probability; increasing resilience; preventing surprises; emergency management</td>
</tr>
<tr>
<td>I. Precautionary</td>
<td>uncertain</td>
<td>uncertain</td>
<td>implementing precautionary principle; developing substitutes; improving knowledge; reduction and containment; emergency management</td>
</tr>
<tr>
<td>Discursive</td>
<td>high or low</td>
<td>high or low</td>
<td>consciousness-building; confidence-building; introducing substitutes; improving knowledge; contingency management</td>
</tr>
</tbody>
</table>

3 RISK EVALUATION AND RISK MANAGEMENT AS A SYNTHESIS OF ANALYSIS AND DELIBERATION

In the deliberative democracy many political and societal problems and their potential solutions remain contentious, albeit the actors in the political arena attempt to achieve consensus on the choice of the appropriate regulations and measures. A deliberative process encompasses public debate and consultation expressing the various interests and values of the affected population. This democratic political action should be characterized by transparency and discourse (cf. Miller 1993; Giddens 1994). Because there are different means for reaching a consensus, actors in the society should agree on the norms and procedures for evaluating political decisions or managing controversial questions and issues rather than assuming a latent consensus on the substantive issues. If the resulting decisions reflect the deliberation of a previous discourse, the legitimacy of the political decisions increases (Miller 1993).

Central to our concept of risk evaluation and management is the attempt to initiate a deliberative process, because rational criteria of evaluation are used, applied in discursive settings and communicated to the public at large. The deliberation of an adequate risk policy should take place within a multistage communication process that is characterized by forms of mutual consultation and a public net of communication.

To assure a rational risk evaluation and an effective risk communication and deliberative process, profound scientific knowledge is required, especially with regard to the main criteria of risk evaluation – probability of occurrence, extent of damage and certainty of assessment — and to the additional criteria as well. This knowledge has to be collected by scientists and risk professionals who are recognized as leading authorities in the respective risk field. The experiences of risk experts from different technological or environmental fields crystallize into a comprehensive body of risk knowledge. The systematic search for the ‘state of the art’ leads to the knowledge base that provides the data for each of the eight evaluation criteria. If there is dissent among experts about the factual assessments or their meaning for risk evaluation, special techniques of classification such as Delphi procedures or meta-analyses may be required to overcome disagreements, to provide calibration for non-substantial differences in expert elicitations and to produce defensible arguments for different positions within the rules of scientific reasoning.

For example, in the framework of the latest annual report about the management of global risks the ‘German Scientific Advisory Council on Global Change’ characterized a number of risk potentials on the basis of the eight criteria and developed respective management strategies (WBGU 1999). The results were compiled by leading scientists who were aware the relevant insights and able to reflect the ‘state of the art’. The results of these considerations were then communicated to the respective ministries (environment as well as science and research).

Getting the best scientific input into the risk evaluation process is only the first yet crucial step in a rational risk management procedure. The interpretation of these pieces of knowledge and
its interpretation into meaningful picture demands both expertise and public values. Value inputs are necessary on at least three levels: The first set of value judgments refer to the list of criteria on which acceptability or tolerability of risks should be judged, the second set of values judgments determine the trade-offs between criteria, and the third set of values refer to resilient strategies for coping with remaining uncertainties and vulnerabilities. Using informed consent on all three value inputs does not place any doubt on the validity and necessity of applying the best technical expertise to the task of defining and calculating the performance of each option on each criterion. Both inputs complement each other. How can this integration be accomplished?

The much cherished solution of the past has been to have expert panels feed in the facts and have democratically elected representatives to reflect these facts on the basis of public values and make informed decisions (Webler and Renn 1995). This so called decisionistic model of deliberation has several major flaws: The selection of facts relies largely on the choice of concerns, and the value preferences of the elected representatives are at least partially dependent on the knowledge about the likely consequences of each decision option. Separating facts from values by division labor leads to a vicious cycle. In addition, uncertainty about consequences, ambiguity of knowledge base, and dissent among experts make it necessary that decision makers interact directly with experts and get an impression of the present state of the art. At the same time, those groups and individuals who are exposed to the risk demand that their values and preferences are taken into account directly by risk managers without the detour of activating the often only remotely affected political representatives (Webler 1998).

Given that situation, it seems justified and desirable to bring scientists, policy makers, stakeholders, and citizens affected by a decision together and initiate a common deliberative discourse. This particularly necessary if highly controversial risks are at stake. The main task of the discourse will be to classify the risks according to a common rationale (such as the one suggested here) and to devise risk management that handle the problems, uncertainties and ambiguities involved in regulating these risks. The main lesson of past risk communication efforts has been that scientific expertise, rational decision making, and public values can be reconciled if there is a serious attempt to integrate them.

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IT RISK MANAGEMENT - A BUSINESS PERSPECTIVE

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In the financial world information technology (IT) and IT risk management are on the 'radar screen' of the major regulatory bodies in Europe and the United States. Current views of IT risk tend to focus on the technology issues. However, in today's IT enabled world the business issues around IT must be fully understood and managed within a common risk framework. Also, by developing a broader vision of IT risk, as an explicit part of IT management, the business managers will be able to fully understand the IT risks they are facing.

This paper explores the core issues and presents a framework for IT risk that looks at risks along the complete IT lifecycle. It presents the subject in business terms and provides some guidelines for the IT management community to ensure business buy-in.

The major points covered include:
* Current thinking of the different regulators.
* The overriding questions IT and business managers are facing.
* The context for managing IT risk.
* An overall IT risk framework.
* The underlying principles for defining the framework.
* The approach to driving out the appropriate metrics.

In conclusion, the paper will describe how the principles and approaches may be used in other areas of risk management.
ACHIEVING A POSITIVE RISK MANAGEMENT CULTURE - “MAKING IT HAPPEN AND MAKING IT STICK”

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Three major areas need to be addressed in developing a sound and practical risk management system; namely, managerial, technical and cultural. It is undeniable that achieving improvements requires attention to technical aspects (risk assessment, specific training etc) and normal management systems (organisational responsibilities, documents etc). However, an emphasis on these aspects alone can encourage a perception of health, safety and the environment as being something different - a subject best solved through technical solutions by a specialist. Successful risk management also requires attention to individual attitudes and perceptions - the most difficult part of the equation.

This paper will explore these concepts in relation to a number of relatively small business units forming part of a large multinational company which has a world-wide reputation for streamlined management structures. Traditional types of safety training and other interventions had been tried. However, the financial impact from continued incident losses demonstrated that this approach was not effective.

The businesses recognised that an integrated approach was required where the principles of business risk and finance could be applied to the management of health, safety and environmental risks. They also realised that the strengths and weaknesses of their organisational cultures needed to be categorised in order to define improvements in attitudes and commitment. Various mechanisms were used to develop integrated management systems and attitude changes as the initiatives evolved. In other words, the initiatives kept pace with changes in the cultural aspirations and therefore, were seen to involve and benefit the line management function and all employees rather than an imposition of some "off the shelf" model.

With the positive support and commitment of the Executives, this has resulted in risk management becoming part of the daily agenda on the shop floor and is self-managed at this level. The financial benefits have been demonstrated through encompassing loss control as an inherent part of the business management.
INTRODUCTION

Aim of this paper is to develop risk indices relevant to labor conditions, considering a single worker, or a group of workers.

In the first case an individual risk index is defined, while in the second one a collective risk index is assessed in order to measure the risk levels.

Individual risk index can be used for ranking the exposures of different workers, assessing priorities and choices in order to get, as much as possible, an equal risk level between the employees.

Collective risk index is appropriate to get a risk measure at aggregate level: division, department, factory, etc. As in the previous case, through this index it is possible to compare different situations within the same factory or plant, or to compare two similar situations, such as two similar plants.

Moreover, both individual and collective risk indices can be used to monitor the evolution during the time of a specific situation, getting insights about improvements or deterioration.

RISK CURVES - VS. - RISK MATRIX

Risk analysis for labor conditions is required today by several European Directives. Very often it is impossible and/or unreasonable to develop a quantitative risk assessment, based upon the well known risk curves, such as those given by the well-known equation $R = P \times D$, where $R$ is the Risk, $P$ the event occurrence frequency and $D$ the damage, in the plane $(P, D)$. More conveniently, a qualitative risk assessment can be used and, in this contest, the so-called risk matrix (see Figure 1) is one of the most popular tools for doing that (sometime this is called semi-quantitative approach). Risk curves and risk matrix are strictly liked, as far as the latter derives from the former, through the substitution of numbers with expert judgments. In particular, the relation between frequency and damage is maintained, on a qualitative basis, and the role taken by the iso-risk curves in the continuous domain is covered by the iso-risk cells (labeled with the same numbers in Figure 1; these numbers may be considered the risk indexes for specific single situations) in the matrix configuration. So, it may be investigated the possibility to formulate well-known quantitative entities, such as individual and societal risk (developed for major risk analysis and, so, for population risk assessment), in a qualitative context, appropriated for labor risks and worker safety. This is done in the following paragraphs.
QUANTITATIVE AND QUALITATIVE INDIVIDUAL RISK

In this paragraph, the individual risk definition is reviewed in order to deal with qualitative risk evaluations based upon the risk matrix. The different risk situations can be considered through probability and damage levels judgments and, provided a proper exposure time weighting procedure, an individual risk index can be computed for each worker, in relation to his/her labor conditions.

Letting $IR(x,y)$ be the individual risk, relevant to the location $(x,y)$, to $i=1,...,N$ events with frequency $F$, each implying up to $d=1,...,M$ types of damage $D$, we have:

$$ IR(x,y) = \Sigma_i F_i \Sigma_d D_{di} = \Sigma_i IR(x,y)_i \quad . (1) $$

Considering, now, the risk matrix and the labor condition, and defining:

- a task index,
- a action index; a task is usually decomposed into few (elementary) actions,
- $C_{taj}$ risk index (i.e., for example in Fig.1, the numbers in the matrix cells) relevant to the $j$th risk situation, with $j=1,...,J_a$ (i.e., the risk situations of action "a" and task "t"),

the individual risk index for action "a" is

$$ IR_{ta} = \Sigma_j IR_{taj} = \Sigma_j C_{taj} \quad , (2) $$
while, the individual risk index for the entire task can be defined as:

$$\text{IR}_t = \sum_a \text{IR}_{ta} \, \theta_a$$

where $\theta_a$ is the ratio between the time spent in the action “a” and the total task time, usually equal to 8 hours/day.

## Societal and Collective Risk

In order to get a global insight about safety of a labor situation - i.e. a laboratory, a division a plant, a factory, etc. - the worker distribution must be considered. Following the analogy with societal risk definition (which is given by the summation of the individual risks weighted with the population distribution), a collective risk index has been developed for this purpose.

Letting:

- $W_{tk}$ the number of employees, with task “$t$”, working in the department “$k$”,

the task/department collective risk can be defined as:

$$\text{IC}_{kt} = \text{IR}_t \, W_{tk}$$

The department collective risk can be defined as:

$$\text{IC}_k = \sum_t \text{IR}_t \, W_{tk}$$

with “$t$” summing all the department tasks.

Moreover, a factory (or global) collective risk can be assessed as

$$\text{IC}_f = \sum_k \text{IC}_k$$

So, the factory collective risk is given by the sum of all department collective risks, which take into account all the task individual risks, weighted with the employees distributions.

A further development of risk indexes can be done by extending the so-called F/N diagram developed for major hazards, which links the frequency to the damage magnitude, and this will be done in a further development.

## How Risk Indices Can Be Used

The relations given in the previous paragraphs may appear a little bit over complicated, and they really are too expensive for simple situations. However, in order to manage the risk in complex labor conditions, we need to combine the risk indexes given by the risk matrix for the single risk situations.

It should be apparent that the risk indices for labor conditions, developed in the previous paragraphs, can be used to:

- optimize the individual risk levels, making each of them as low as possible and as similar as possible,
- get a comparison between different parts of a factory or plant, leading to their risk classification,
- get a comparison between similar plants, also for benchmarking purposes,
- monitor the time evolution, particular trends, etc., of risk levels, through the changes in time of risk indices, letting a proper risk management.
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WHY CHANGING THE WAY TO MEASURE THE RISK?

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ABSTRACT
The SEVESO II Directive gives the rules to identify high risk potential establishments with the amount of hazardous substances handled and their operators have to produce safety reports. Although rules are well established to identify potential risk, there is no method to measure the risk level which takes into account safety devices and safety management systems implemented by operators.

In fact, the lack of rules to integrate the prevention made by operators has negative effects:
- Operators are not encouraged to increase the risk prevention,
- Risk decision-makers have no clear opinion of the real risk level,
- The risk expert’s job is tricky because of the lack of method to identify reference scenarios.

Furthermore, the risk level is appreciated in fact throughout an effect distance. This way is too simple to give a pertinent enough risk assessment. In fact, risk evaluation should include other parameters to be more representative: the area concerned by the phenomenon, its kinetic, the ability to generate domino effects.

Because of all above reasons there is a need to define rules to identify scenarios integrating the prevention made by the operators and then to evaluate them by taking into account the characteristics of the phenomenon involved.

CONTEXT AND REQUIREMENTS OF THE COUNCIL DIRECTIVE 96/82/EC
The Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances, known as SEVESO II Directive, aims at the prevention of major accidents and the limitation of their consequences for man and environment, with a view to ensure high levels of protection throughout the European Union in a consistent and effective way. It applies to industries that use a significant amount of materials that are hazardous to people and the environment. Operators of such industries must demonstrate that they have assessed the risks and are managing it, that they have a policy for the prevention of major accidents and a safety management system, and that finally they have adequate response plans in case of emergency.

Accordingly, a better management of hazards is necessary. Also tools have to be used to help the operators to carry out the risk analysis and to build a safety management system. Such tools have to be recognised by the Public Authorities and the decision-makers in charge of risk control. After reading the Directive, the objectives in terms of risk management are clearly laid down but the remaining question is: how to reach them?

As the documents produced by the operators have to be demonstrative, it would be useful that the analysis led by the operators follows a recognised methodology. The multiplicity of methods for the evaluation of major accident hazards as a result of difference of cultures,
makes it difficult to propose a harmonised procedure. However, some aspects of the different approaches can be put in common such as scenario identification and gravity evaluation.

PERVERSE EFFECTS OF THE LACK OF ADEQUATE METHOD TO MEASURE THE RISK

Although rules are well established to identify risk potential on the base of the quantity of dangerous substances (Annexe I of the Council Directive 96/82/EC), there is no commonly recognised method to measure the risk level of units, which takes into account safety devices and safety management system implemented by operators.

In fact, the lack of rules to integrate the prevention made by operators has negative effects:

1. Risk prevention not encouraged

Often, after identification of the establishments covered by the Directive, its risk is perceived by the Authorities and the decision maker mostly throughout the use of safety distances taken from the safety report. For example, articles 11, 12 and 13 may all give rise to a concept of ‘zones’ around a SEVESO establishment linked to, respectively [2]:

- Emergency planning;
- Land-use planning;
- Information to the public on safety measures and behaviour in the event of an accident.

It follows that for the population and for some actors involved in risk management at a geographical scale, the risk level of an establishment is directly proportional to the safety distances or safety areas allocated for the above mentioned uses. Finally, the most commonly used risk level index is scaled in meters.

The perverse implication of such an implicit index is that operators are urged on restricting the consequence of the scenario by implementing protective devices like water curtains, detection systems connected with quick closing valves... On the other hand, prevention has no benefit on the effect of major accident scenarios because it does not reduce its consequences. That is why operators are not encouraged to improve the prevention. This statement must be also linked to the fact that the majority of the major accidents reported in the Community are the result of managerial and/or organisational shortcomings. Besides, it also must be noticed the new occurrence of so called ‘post SEVESO accidents’ which involved failure of safety devices [4], that suffered from non appropriate maintenance and testing.

To sum up, on the one hand, the Council Directive 96/82/CE asks efforts from the operators to demonstrate that they implemented a major-accident prevention policy and a safety management system, on the other hand, the uses and in particular the zoning established from these documents (safety report), do not urge an efficient prevention policy. The SEVESO Directive, viewed as a good example of ‘goal-setting’ legislation needs, in addition, the development of a methodology, first, in order to guide the choice of reference scenarios that have to be selected in function of their use (emergency plans, land-use planning, acceptance of siting new establishments). Second, a risk level evaluation that would take into account the prevention made by the operators would encourage them to invest in actions to improve the efficiency of the safety management.

2. No clear opinion of the real risk level

In the first part, it was demonstrated that the risk level of an establishment is perceived through the safety distance reserved around the plant for land-use planning or for emergency plans. But the quick analyse of major accidents, in comparison with the safety distances around industrial sites shows a great gap.
• Safety distances in case of toxic releases are widely beyond the limits of the establishment (often more than 1 or 2 km). However, except the accident at Bhopal in 1984, the accident reports only mention some injuries, sometime serious and within these limits [6, 7].
• On the contrary, safety distances in case of flammable releases are often inside or in the close neighbourhood of the establishment (300 to 500 m). However, the accidents reports often mention fatalities and serious injuries, further away [6, 7].

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Event Description</th>
<th>Impact Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnesville, USA</td>
<td>June 1981</td>
<td>Release during 25 minutes of 40-50 tons of anhydride ammonia from a storage</td>
<td>30 persons injured (8 seriously) some of them were drivers on a motorway nearby, who lost control of their vehicle or tried to run away on foot</td>
</tr>
<tr>
<td>Asfeld, Germany</td>
<td>January 1990</td>
<td>Rupture of a 25 mm pipe during the unloading of a chlorine rail tank car to a 50 tons storage</td>
<td>Inhabitants were in the vicinity of the plant: 120 persons sent to hospital and 5 persons seriously intoxicated</td>
</tr>
<tr>
<td>Flixborough, UK</td>
<td>June 1974</td>
<td>Leakage in 2 reactors caused the explosion of 40 to 50 tons of cyclohexan</td>
<td>28 fatalities, 89 injuries All construction destroyed within a radius of 600 m Windows broken within a radius of 13 km, big fragment at 6 km</td>
</tr>
<tr>
<td>Pasadena, USA</td>
<td>October 1989</td>
<td>Explosion of ethylene and isobutanol in a chemical unit producing polypropylene</td>
<td>23 fatalities, 124 injuries Plant completely destroyed Windows and walls damaged within a radius of 7 km</td>
</tr>
</tbody>
</table>

Example of accidents given in document [6]

In the case of ‘tables of appropriate separation distances’ use for instance in Sweden [2], it can be noticed that the greatest separation distances also are for toxic products. This general trend demonstrates that the safety distances for toxic release seems to be overpredicted in comparison with the safety distances for flammable substances. This trend can be analysed both for consequence based approach and for risk based approach.

3. No consistent approaches
In fact, risk experts from all EU countries mostly agree with the major accident scenario. When asking different experts from European Countries about the definition of the scenario chosen and evaluated in the safety reports, the answers will not always be the same. In fact, there is no recognised definition of the major reasonable, credible or realistic scenario. Generally in France, because of the French consequence based approach, the scenario chosen are such as BLEVE, total instantaneous loss of containment, instantaneously rupture of the largest pipeline leading to the highest mass flow, fire in the largest tank, explosion of the largest mass of explosive... [2, 3] However sometimes, the urban constraints of residential area development or new road constructions in the vicinity of existing establishments urge the company to reduce the safety distances. Then it is proposed to choose a more ‘realistic’ scenario than the previous one, by taking into account the efficiency of mitigation devices that already existed or that will be implemented. In fact, because of the lack of rules for identifying the scenario, the expert’s job is tricky. He can’t rely on an established method to put aside the major scenario and to choose other scenario characteristics.
Because of all above reasons there is a need to establish rules to identify scenarios integrating the prevention made by the operator and to propose a method for their evaluation. This evaluation will allow to properly measure the risk of a unit depending on the phenomenon involved.

**A new method for risk evaluation**

First, it is proposed to define a method giving rules for the identification of scenarios that take into account mitigation devices and risk prevention actions. Then the evaluation of the scenario should consider more representative parameters than distances, and their evaluation should be calculated by integrating the effect area concerned with the phenomenon, its kinetic, its potential to generate domino effects...

1. **Scenario identification**

The objective is to identify major ‘Reference Scenarios’ regarding the analysis of accidents data bases like MARS [9] and taking into account the current practices (state of the art) contained in the lawful requirements with regard to conception, operation and control, and safety mitigation devices. The reference scenario allows to find more realistic scenarios and to put aside some major scenarios, considering a unit operated today. The Reference Scenario could be identified with an algorithm based on the labelling of the substances (Council Directive 67/548/EEC of 27 June 1967 on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances) and the conditions of use (pressure, temperature...). This scenario is mainly generated by external events (mechanic aggression, thermal aggression, earthquake...) or internal failure that can be identified by studying the process with a method like HAZOP pointing process parameter deviation (runaway reaction, overflowing...).

2. **Scenario gravity evaluation**

In the first paragraph, it has been demonstrated that the risk level is appreciated throughout effect distances. The objective of the gravity evaluation is to calculate a gravity index depending only on physical parameters that makes it possible to compare different scenarios. Taking into account phenomena characteristics implied in scenarios would moderate the measurement of the gravity. For its evaluation, it is proposed to quantify the influence of:

- the effect area $A$ concerned with the phenomenon: a disc in case of an explosion, the projection of a plume for the pollutant gas dispersion;
- the phenomena kinetics $K$: rapid for explosions, slower for dispersion and fires;
- capacity of intervention $I$ to master the disaster or to limit its consequences: possible for fire and gas dispersion, but possible only by conception for explosion;
- potential of domino effect $D$: emission of projectiles, interlocking of delayed phenomena.

The composed gravity index $G$ could then be a function of parameters only associated with the physical phenomena. Then all scenarios identified could be evaluated and ranked with this gravity index. With this index, it could be discovered that toxic substances not always generate the highest risk level.

**CONCLUSION**

This paper emphasises that there is a need to establish a method to measure the risk of an installation by integrating the prevention implemented by the operators, otherwise it will be
difficult to reach the goals of the SEVESO II Directive in all European Country, that are to improve the prevention linked in particular with the management. It is proposed that the method defines rules to identify scenarios integrating the prevention made by the operators and then evaluate them by taking into account the characteristics of the phenomenon involved. The application of this method might result in a more consistent risk evaluation and management in the whole EU. The conclusion of the benchmark exercise under the project ASSURANCE (ASSessment of Uncertainties in Risk ANalysis of Chemical Establishments) would certainly justify the development of such a harmonised method.

References
ARE THERE ACCIDENT-PRONE WORK ENVIRONMENTS?

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This paper considers work accidents under an ecological perspective. Work-accidents are seen as events embedded in a large environmental system, as a product of the transaction between people and their physical, social and organisational environment. Our purpose is to identify the factors accounting for accidents, and how they are mutually related. We hypothesised that work accidents are a consequence of a mismatch between people, their actions, and their work environment.

We compared two burr workshops in the foundry industry with similar equipment and technology having significantly different accident rates over a same period of one year. Data collected concern the transactions between people and the physical features of their work environment, their social and organisational environment, their use of safety protections as well as their perceptions and evaluations of these features.

Results show that the different work accident rates seem to be due to a conjunction of physical, social and perceptional factors. The higher accident rate is linked to lower satisfaction and evaluation concerning the environment and the safety of the work place, higher cohesiveness between colleagues, and frequent changes in machine allocation which impedes work place appropriation. At the opposite, low accident rates goes along with higher satisfaction concerning the work environment and work organisation, positive evaluation and high satisfaction concerning the amount of work space allocated and the lighting conditions, and work organisation is characterised by a specific allocation of a machine and with higher variety of the pieces to work with. Thus accident rates depend no only on the physical and social features, but also on perception and evaluation processes concerning various aspects of the work environment. Such an approach of work accident contributes to enhance accident prevention and safety in an integrated way.
CONSIDERATION OF MANY FACTORS FOR RISK MANAGEMENT

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FOR THE PURPOSES OF MANAGEMENT OF RISK IN A SPACE OF MANY FACTORS THE METHOD OF REVEALING BOTH EVALUATION OF MATHEMATICAL EXPECTATION AND VARIANCE OF MANY-DIMENSIONAL STOCHASTIC FUNCTION IS OFFERED.

Risk management is management of stochastic processes. It can be based only on knowledge of patterns of these processes described in mathematical expectation and parameters (first of all, variance) of random deviation from the expectation. Frequently these patterns can be revealed only by empirical way. The revealing and description of such patterns are complicated because they depend, as a rule, on many factors.

In the capacity of the method of revealing and description of such empirical patterns can be used the method developed by the author. It allows to find such scale of a measurement of basic data (a multifactor table) that they will be described by the sum of the tables dependent on smaller number of the factors in the best way (i.e. with the least variance):

\[ P(\{\varphi(x_1,x_2,\ldots,x_n)\}) = \Sigma f_i(x_i) + \epsilon, \]

where \( \varphi(x_1,x_2,\ldots,x_n) \) is the basic data dependent on \( n \) of factors (variables) \( x_1,x_2,\ldots,x_n \); \( P \) is definitely normalized and beforehand unknown nonlinear transformation (a polynomial from \( \varphi \)); \( f_i(x_i) \) is table of numbers dependent on a combination of variables \( x_i \) containing number of variables smaller than \( n \). \( \Sigma f_i(X_i) \) can be considered as expectation of an random value \( P(\varphi(x_1,x_2,\ldots,x_n)) \), and \( \epsilon \) as a random deviation from the expectation.

If \( P(\varphi) = \varphi \), this method is identical to Fisher's "Design of Experiments".

As well as Fisher's method this method requires the basic data which must be ordered like a table, but in practice to gather the date by this way can no always. The way out can be found either with the help of interpolations or with the help of neuron network in order that to create the table.

Efficiency of the method has been confirmed on many tens of problems that could seemed as insoluble.

Example:
In work of E.B.Rabkin, the known expert on colour sight, thresholds of color-sighting after adaptation to various levels of a saturation of colour fields at normal and anomalous trichromats were investigated. The examinees were adapted 10 minutes to red colour field (=650 nm) or to green one (=540 nm) in two variants of a saturation (100 and 30 %). After adaptation the thresholds of spectral sensitivity were investigated. Under observation there were groups of normal trichromats (10 persons), deuteranomal ones of type B (13 persons), and protanalom ones of type B (7 persons). The outcomes of observations are indicated in the
Table 1, where M is average significance of thresholds of color-sighting (distinguishable nuances), and m is the standard deviation of the average significance.

Table 1. Number of levels of color perception (M±m)

<table>
<thead>
<tr>
<th>Spectrum zone, nm</th>
<th>Preliminary adaptation, λ, nm</th>
<th>Saturation of adaptation color, %</th>
<th>Normal trichromat M±m</th>
<th>Deuteranomaly of type B, M±m</th>
<th>Protanomaly of type A, M±m</th>
</tr>
</thead>
<tbody>
<tr>
<td>665-620</td>
<td>650</td>
<td>100</td>
<td>20±0.72</td>
<td>16±0.51</td>
<td>14±0.43</td>
</tr>
<tr>
<td></td>
<td>540</td>
<td>100</td>
<td>30±1.23</td>
<td>19±0.31</td>
<td>18±0.1</td>
</tr>
<tr>
<td>540-520</td>
<td>650</td>
<td>100</td>
<td>23±0.73</td>
<td>17±0.31</td>
<td>14±0.13</td>
</tr>
<tr>
<td></td>
<td>540</td>
<td>30</td>
<td>32±1.1</td>
<td>19±0.12</td>
<td>18±0.61</td>
</tr>
</tbody>
</table>

With standard error of 5 %, which corresponds to the accuracy of the initial data, they are approximated in kind:

1.61·M - 0.232·M² = f₁(Spectrum zone, Kind of sight) + f₂(Saturation, Kind of sight).

The functions f₁(Spectrum zone, Kind of sight) and f₂(Saturation, Kind of sight) are reflected in Tables 2-3.

Table 2. f₁(Spectrum zone, Kind of sight)

<table>
<thead>
<tr>
<th>Spectrum zone, nm</th>
<th>Normal trichromat</th>
<th>Deuteranomaly of type B</th>
<th>Protanomaly of type A</th>
</tr>
</thead>
<tbody>
<tr>
<td>665-620</td>
<td>23.60</td>
<td>20.25</td>
<td>18.52</td>
</tr>
<tr>
<td>540-520</td>
<td>16.21</td>
<td>8.82</td>
<td>6.94</td>
</tr>
</tbody>
</table>

Table 3. f₂(Saturation, Kind of sight)

<table>
<thead>
<tr>
<th>Saturation of adaptation color, %</th>
<th>Normal trichromat</th>
<th>Deuteranomaly of type B</th>
<th>Protanomaly of type A</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>30</td>
<td>4.22</td>
<td>1.96</td>
<td>2.41</td>
</tr>
</tbody>
</table>

The created model is nomographable. The nomogram is showed on Fig. 1.

It is interesting to note following: the authors of the article have not noticed, that the number of thresholds does not depend on the color at which adaptation was conducted. Probably this fact was not noticed by them only because it contradicted to regular system of representations in about the investigated phenomenon.
Kind of sight:
A - Normal trichromasy.
Á - Deuteranomaly of type Á.
Å - Protanomaly of type Å.

Spectrum zone:
1. 620-665 nm;
2. 520-540 nm.

Saturation of adaptation color:
α. 100%;
β. 30%.

Fig. 1. The nomogram for number of levels of color perception. (The number of levels is equal to distance on scale between points "saturation of color at adaptation" and "spectrum zone" for chosen kind of sight)

3 E.B. Rabkin and others, "Thresholds of color-sighting after adaptation to various levels of saturation of colour fields at abnormal three-chromats", Reports of SU’s Academy of Science, Vol. 228, No. 1, 1976, p. 242-243, ru.
Table 6: 

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter A</td>
<td>120</td>
<td>20</td>
</tr>
<tr>
<td>Parameter B</td>
<td>80</td>
<td>10</td>
</tr>
</tbody>
</table>

The standard error of the mean is calculated as the standard deviation divided by the square root of the sample size. This is an important consideration in statistical analysis, as it provides a measure of the precision of the estimate.

The results obtained from the analysis are presented in Table 6. The values for each parameter are shown, along with their respective standard deviations. The mean values provide a central measure of the data, while the standard deviations indicate the variability around this central value.

In conclusion, the results obtained from the analysis provide valuable insights into the parameters under study. The precision of the estimates is further supported by the low standard errors, which indicate a high level of confidence in the results.

It is interesting to note, however, that the number of observations did not significantly impact the precision of the estimates. This suggests that the current sample size is sufficient for accurate analysis, and that further increases in sample size would likely not lead to significant improvements in the precision of the estimates.
TRACK 2

SESSION 5

RISK MANAGEMENT APPLICATIONS
BARRIERS TO THE ADOPTION OF GOOD HYGIENE PRACTICE BY SMALL AND MEDIUM-SIZED FOOD BUSINESSES: A CASE STUDY OF READY TO EAT MEAT PRODUCTS MANUFACTURING.

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BACKGROUND

Increasing rates of food poisoning in Europe and the US in the 1980s indicated that quality control through end-product testing was no longer adequate to ensure food safety (POST, 1997). Codex Alimentarius (Hathaway, 1993), NACMCF (1992) and ICMSF (1988) have all advocated the introduction of stricter safety specifications for foods in local and international trade. The high media profile of food poisoning outbreaks has led to major inquiries, the recommendations of which have precipitated regulatory and legislative action (AC, 1998; The Stationery Office, 1997; DH, 1990 and 1991). Hence, the 1990s has been a decade in which substantial changes in food safety legislation in Britain, Europe and internationally have taken place. Control measures aimed at the prevention of specific pathogens may vary. Since it is the agreed task of government to maintain the level of risk from foodborne illness at the minimum which is technologically feasible, approaches to prevention must therefore target all routes to contamination and infection. Council Directive 93/43/EEC (on the Hygiene of Food Stuffs) brought with it a new definition of 'hygiene'. Whereas, previously there was a common acceptance that hygiene referred to 'cleaning and the schedules, equipment and procedures involved in the business of cleaning' (Kane, 1995), the new definition includes 'all measures necessary to ensure the safety and wholesomeness of foodstuffs' (Article 2). Consequently, the concept of good hygiene practice has been introduced into European food safety legislation to foster a proactive and preventative approach to food safety. Directive 43/93 requires food businesses to employ HACCP1 principles also (Article 3). This extends the scope of the previously available standard for good manufacturing practice2 (IFST, 1987 and 1991). Directive 93/43/EEC requires member states to encourage the development of 'guides to good hygiene practice'. These guides are produced through the cooperation of industry and government (the Department of Health). Guides have so far been produced for retailing, catering and baking but not for the manufacture of ready to eat meat products, except meat pies which are covered by the Baking Guide. However, Assured British Meat is expecting to produce guides to cover the entire food chain of meat production in due course. In the absence of industry guides, manufacturers are forced to rely on one of three types of industry standard:

- First or second party audit (customer specifications)
- Third party audit
  - Trade organisation standards (eg. BMMA3)
  - Accreditation agency standards (eg. EFSIS, LawCred, PROcheck)

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1 Hazard Analysis and Critical Control Point
2 GMP identifies the parameters of procedures and control of procedures (in the form of training, monitoring and documentation to provide evidence or traceability) for personal hygiene, detergency, pest control, foreign body management and contents control
3 British Meat Manufacturers Association
4 European Food Safety Inspection Service
The aim of this study was to assess the problems faced by small companies in achieving an upgrade of hygiene systems through a case study of ready to eat meat products manufacturers. Despite national differences in reporting procedures, variation in prevalence of specific pathogens between countries, and varied culinary customs, meat and meat products are significant vehicles of infection in most countries (Sockett, 1995). Ready to eat meat products are categorised as high risk and meat pies for fresh consumption as medium to high risk (ACMSF, 1990). These foods are not intended to be cooked by the consumer prior to consumption and consequently processing and handling are of vital importance in ensuring their safety. Manufacturers of these products, not supplying to the final consumer, are required to be approved under the Meat Products (Hygiene) Regulations 19945. The Regulations contain some prescriptive conditions relating to the construction and layout of premises, facilities provided within the premises and general conditions of hygiene.

CASE STUDY METHODOLOGY

Case study was used because it provides the flexibility required by both policy and organisational research. Organisations are stakeholders in policy implementation and findings from a small number of sites sharing similar conditions can be of significance to policy makers (Smith and Robbins, 1982). Case studies involve on-site data collection which permits analysis within the context of the organisation and allows the tracking of change over time (Yin 1993 and 1994). In addition, quantitative and qualitative methods can be used alongside each other (Creswell, 1998). Twenty-four businesses were selected, each treated as a separate entity with its own circumstances and characteristics. Companies were recruited through a questionnaire distributed to a random sample of businesses registered as approved under the Meat Products (Hygiene) Regulations 1994.

Objective records were obtained through a hygiene audit conducted to the EFSIS protocol by a qualified auditor. Interpretive accounts, of the development of hygiene standards and awareness of the audit findings, were obtained through in-depth interviews. A semi structured interview procedure was followed deemed appropriate for situations where (King, 1997):

- factual information is to be collected but there is uncertainty about what and how much information participants will be able to provide
- the nature and range of participants' likely opinions about the topic are not well known in advance and cannot easily be quantified

Interviews were conducted either with owner-managers or technical managers. Interviews were taped and transcribed. Transcripts were coded following familiarisation with the data and then edited using 'cut and paste' (Crabtree and Miller, 1992). Cross-case analyses were prepared with emphasis on data reduction and organisation (King 1997). Validity was achieved through convergence, intersubjectivity, challenging the data and the incorporation of feedback loops at all stages of the research (Cherryholmes, 1988; Stake, 1995).

Frameworks

Two theoretical frameworks were used to organise the analysis of cases:

<table>
<thead>
<tr>
<th>The Implementation process</th>
<th>Resources Available to the Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of the need for change</td>
<td>Informational</td>
</tr>
<tr>
<td>Understanding of the changes required</td>
<td>Technical</td>
</tr>
<tr>
<td>Motivation to make the changes</td>
<td>Motivational or Strategic</td>
</tr>
<tr>
<td>Ability to make the changes</td>
<td>Physical, Financial, Human</td>
</tr>
</tbody>
</table>

CLASSIFICATION OF COMPANIES
On the basis of analysis of the interviews and audit reports, the companies were categorised as follows according to their level of motivation:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>4</td>
</tr>
<tr>
<td>II</td>
<td>8</td>
</tr>
<tr>
<td>III</td>
<td>4</td>
</tr>
</tbody>
</table>

Third party certification or the EFSIS standard in particular was perceived to be prestigious whether or not it was required by customers/prospective customers.

| IV | 8 |

Third party certification was deemed unnecessary and/or was perceived as too high a standard for the company.

CHARACTERISTICS OF COMPANIES
Category I - Four companies in this category required approval because they had been requested by customers to become third party accredited.

<table>
<thead>
<tr>
<th>Informational</th>
<th>All satisfied with the availability of information (sources trade associations, publications, mixed) and familiar with the EFSIS standard although not necessarily of specific requirements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>All employed a technical manager. All HACCP plans were passed at audit.</td>
</tr>
<tr>
<td>Strategic</td>
<td>Companies in this group were supplying to the mass market. All supplying large customers but not supplying multiple retailers. All had experienced full audits.</td>
</tr>
<tr>
<td>Physical</td>
<td>High and Low care was segregated by through cookers or hatchway. All plants were factory based. None were rural businesses.</td>
</tr>
</tbody>
</table>

Category II - Eight companies perceived third party certification to enable expansion of the business to include large customers, whether or not the company was already in negotiation with prospective customer(s).

<table>
<thead>
<tr>
<th>Informational</th>
<th>Three out of eight companies were satisfied with the availability of information (sourced from trade association or multiple sources). Five had heard of the EFSIS standard.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>Three companies employed technical managers, two of these were approved. The two approved premises had either an adequate HACCP system or needed only a very minor correction. One other company had an adequate HACCP system (a slicing/packing operation).</td>
</tr>
<tr>
<td>Strategic</td>
<td>Three companies were manufacturing traditional products. Two companies traded with large customers, the remainder wanted to. No companies traded with multiple retailers and only three companies wanted to. One company specifically did not want to trade with multiple retailers (traditional product). Six had experience of audits, one of visits, two of questionnaires.</td>
</tr>
<tr>
<td>Physical</td>
<td>Four companies with through cookers, one German alarmed-door system, three were segregated by area/room. Plants were either factory or unit, only one was a farm/rural based business.</td>
</tr>
</tbody>
</table>
### Category III

<table>
<thead>
<tr>
<th>Informational</th>
<th>Two companies were satisfied with the availability of information (source, trade association and publications) both were aware of EFSIS. One was not satisfied but aware of the standard, one was not satisfied nor aware of EFSIS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>One company employed a technical manager and was approved. No HACCP systems were passed.</td>
</tr>
<tr>
<td>Strategic</td>
<td>One company, which employed a technical manager and was already trading with large customers and multiple retailers, was motivated by the cudos of EFSIS because of its emphasis on the management of systems. One company, manufacturing a specialist traditional product, was hoping to trade with large customers. Two companies were not motivated to trade with large customers although one recognised it may have to supply to multiple retailers eventually as the number of small retailers diminishes. Two companies had experienced audits.</td>
</tr>
<tr>
<td>Physical</td>
<td>The company with a technical manager used the German alarmed-door system, the others segregated either by area or time. Mixture of plant types, one rural business.</td>
</tr>
</tbody>
</table>

### Category IV

<table>
<thead>
<tr>
<th>Informational</th>
<th>Three companies were satisfied (sources industry contacts, publications), two were aware of EFSIS. Five were not satisfied, one was aware of EFSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>One company employed a technical manager but did not pass the audit. One other company had an adequate HACCP</td>
</tr>
<tr>
<td>Strategic</td>
<td>Four companies manufactured traditional products (all rural businesses). One company employed a technical manager and was already trading with large customers but was not motivated because it intended to achieve the standard instead and was therefore exceptional in this group. seven companies specifically did not wish to trade with multiple retailers. Only three companies had experience of audits. Three companies had not received visits or questionnaires.</td>
</tr>
<tr>
<td>Physical</td>
<td>Three companies segregated with through cookers, two by area, three by time. Four were rural businesses.</td>
</tr>
</tbody>
</table>

### BIBLIOGRAPHY


In recent years several studies in the UK have been conducted, investigating the adequacy of ground investigation practice and the role ground-related problems play in the achieving of the objectives on projects in the building and construction industry. The studies seem to indicate that cost and time overruns on a significant proportion of projects can be attributed to ground-related problems. A two year project, funded by the British government and the Institution of Civil Engineers, were recently launched to develop a strategy for managing geotechnical risk in the building and construction industry. The paper will discuss some of the findings of the research so far.

The paper will attempt to put ground-related risk and the management thereof into context. The categories of geotechnical risk will be briefly discussed. Different methods of managing these will be illustrated, emphasising the importance of selecting the most appropriate project organisation. Finally, integration of geotechnical risk management into a project wide risk management process, including all disciplines involved, will be discussed and. It will be shown that geotechnical risk management can be integrated into the general risk management process on a project without any disruption.
THE INDUSTRIAL SAFETY PROMOTION AT OIL AND GAS DEPOSITS IN THE SHELF OF FREEZING SEAS

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Abstract
Traditional parameters of industrial safety in oil and gas industry are number and categories of accidents; number of accidents, victims and death roll. This it is not enough for organization of an effective risk management system on oil and gas deposits in the shelf of freezing seas. With reference to such conditions as parameters of industrial safety it is necessary to consider: expected social risk; expected volumes of not planned losses; a level of insurance protection. In work the features of industrial risks management in oil and gas deposits in the shelf of freezing seas are considered.

Introduction
Every company maintaining in oil and gas deposits in the shelf of freezing seas is interested in stable development. Emergencies, accidents, the industrial malfunctions conduct to losses, hinder with stable development of such companies. In the correspondence with article 1 of the Russian Law "About industrial safety of dangerous industrial objects" industrial safety is a condition of security of the vital interests of the person and society from accidents on dangerous industrial objects and consequences of the indicated accidents. With reference to interests of oil and gas companies under industrial safety it is necessary to understand a condition of security of interests of the companies and their employees from accidents on dangerous industrial objects and consequences of the indicated accidents. Therefore, the organization of an effective management system of oil and gas company as a whole (and industrial risks management, in particular) should be based on monitoring of appropriate parameters of industrial safety.

The main results
Traditional parameters of industrial safety in oil and gas industry are: number and categories of accidents; number of accidents, victims and death roll. The indicated parameters do not reflect: Real economic losses from accidents, industrial malfunctions and emergencies, that is not planed losses;
- Efficiency of the realized preventive measures;
- Economic validity of the costs for reaching a required level of industrial safety;
- Adequate risk level, that is level of industrial safety of company as a whole.

Therefore it is not enough for organization of an effective risk management system on oil and gas deposits in the shelf of freezing seas.

The results of the analysis of available experience allow to determine as parameters of industrial safety for oil and gas company the following parameters [1]:
Actual volumes of not planned losses of the company;
Expected levels of industrial risks;
Level of insurance protection for objects of the company

The not planned losses in present work are [2]:

- The price of replacement of failed basic production assets, materials;
- Compensation of the responsibility for causing of harm to life, health or property of other persons and environment;
- Losses from breaks of production.
- The price of replacement of failed basic production assets consists from expenses on:
  - Purchase of the new equipment;
  - Delivery of the new equipment;
  - Dismantle of old and installation of the new equipment.

As expected levels of industrial risks is accepted:

- expected volumes of not planned losses for company (per one year);
- expected victims and death roll to accidents at the industrial objects of company.

The last parameter has not an economic nature, but is included in the list of industrial safety parameters, because it reflects social component of losses.

Financial tools, including the insurance, not making zero technical risk, allows to lower to zero risk financial.

The accident losses (not planned on date and size) are passing in the category of insurance payments, planned and quite accepted.

Therefore as one from parameters of industrial safety for oil and gas company the level of an insurance protection of the industrial objects is offered to consider. It is represented especially important for oil and gas deposits in the shelf of freezing seas.

Conclusion

The parameters of industrial safety, offered in the present work, allow estimating:

- Real economic losses from accidents and emergencies;
- Efficiency of the realized precautionary measures;
- Economic validity of expenses for achievement of a required level of industrial safety.

Bibliography

PRECONDITIONS AND PATTERNS OF RISK MANAGEMENT IN RUSSIA

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The paper is based on several research projects undertaken by IN-DEPTH Risk Research Group using statistical and documents analyses, interviews with experts and laymen, and representative surveys on regional and all-Russian samples. It attempts to answer the double question, "What are the social and cultural preconditions and dominant patterns of risk management in Russia?" For this purpose, the evolution of traditions, values and stereotypes during the years of the changes in Russia is discussed. The planned technological and management improvements are aggravated by permanent political and economic crises, hampering and reducing safety budgets. The unsatisfactory state property privatization policy, which has been the key aggravating factor of the last seven years, is emphasized as the source of serious problems of risk management at potentially dangerous production, storage, recycling and transportation companies.

As a consequence of fundamental preconditions, several dominant patterns of risk management were found. They differ considerably for different companies and industry branches conventionally characterized as "serious" or "ordinary" for viable systems of technological monitoring and public and experts participation, "nationalized" or "private" for property and type of management, "megalopolis" or "provincial" for regionally and socio-culturally biased values, "transparent" or "non-transparent" for style of risk management and communication procedures, and "supported" or "not supported" as regards support from local authorities.

The combination of opposite patterns is scrutinized as a part of the complex profiles of "advanced" and "backward" companies with peculiar deficiencies or advances in accuracy and transparency, terms of safety, attention to (or disregard of) environment or profits, orientation to (or disregard of) experts or public, degree of rational approach, "flexibility", pluralism, etc. Possible ways of risk management improvements for both "advanced" and "backward" companies are suggested in the paper.

In the Soviet times, risk almost absolutely did not figure in everyday laymen conversations or as a notion of industrial management highly pressed by the Communist ideology. Risk perception did not transgress the bounds of mere warnings like "to be careful and not to get involved in an accident". The Communist ideology strictly punished any mention of instability of the existing social order or any of its components, including technological, ecological, economic, or political. In the former society, there was no public participation in risk assessments and management, as well as involvement of sociologists or psychologists in
prevailing procedures of risk management. All the decisions were solely “partocratic” and “technocratic”.

Many negative economic and social trends concerning social conflicts, terrorism and large-scale accidents emerged in the late 80s. The objectively dangerous situation evoked multiple changes in the consciousness and values of people, and in patterns of risk management. The non-democratic approach to risk management came under serious consideration after the year 1985, with a view to get rid of its limitations. In military and industrial spheres with highly developed production facilities, the primary importance of the “human factor” was proclaimed. It became the cornerstone of the initial stage of Russian reforms.

In Gorbachov’s times (1985-91), the public participation was proclaimed by academicians Leonid Abalkin and Abel Aganbegyan under the motto of creating the “socialist economy with human face”, while in Yeltsin years (1991-99), it was continued under the motto of creating the “market economy with attention to human factor” (already without “human face”, according to the widespread joke). To ensure public participation in decision-making on risk, a number of measures were suggested. The best managers from all over the country were sent to the United States and Western Europe to learn the new principles of public participation and transparency. However, as the Russian reality and mentality were seriously different, the lessons from the West were rather only heard than practically applied. It was an “entertainment” for the majority of top managers and politicians, due to the obvious impossibility to apply the patterns conflicting with the fundamental patterns of Russian mentality and communication. Western patterns of decision-making on risk were taken in Russia as a purely theoretical experience (dissertations and municipal or corporate reports), criminal experience (appropriation of assets through bogus shares, etc.), or real experience. During this clash between "old and new" mentalities, the former principles won; they were too deeply incorporated into people’s psychology and life. The extrapolation of the long-term Soviet traditions onto the post-Soviet reality evoked non-transparency and inherent non-democracy, despite the proclaimed “full adherence to democratic rules”. Cases of citizens’, amateurs’, laymen’, and non-technical experts’ participation in making important decisions remain too rare. The local communities still have no ability to influence the strategies and tactics of risk prevention and minimization. The situation is also aggravated by low motivation of local authorities to improve the situation. Their motivation embraces “law-breaking privatization of national property”, “bribery”, or “corruption”. The best managers left to join private business, away from the risky state corporations. The state plants with obsolete equipment are managed by the “old epoch” people, i.e. those whose knowledge, technocratic mentality and production facilities “remain at the pre-change level of the year 1985”.

As “mentality change measures” did not lead to any valuable result, “economic measures” were suggested. To improve the situation, “partial or full denationalization” of the companies’ property was undertaken, to change them from nationalized to shareholder or private companies to provide an additional impulse of motivation. Unfortunately, it caused additional instability both during and, mainly, after the process of transformation, in cases of “refreezing” the inadequate “new order of things”. The valuable idea of transformation was hindered by its compressed and indefinite terms, worsening of financial level of companies due to their “transitional” status and work breaks, destructive struggle for power initiated by provocative and dangerous actions by different fighting groups and forces within and outside the companies and industry branches. The transformation took place mainly in three forms, i.e. as a change handed down from municipal or regional authorities, as a result of bankruptcy,
or as an event to pursue the goals of business. The latter was the most rare, only in cases followed after “denationalization”. In each of the three forms, the property came from a larger number of owners to a smaller one, often as a result of betrayal like issuing the bogus shares or vouchers by the directors; the biggest industrial complexes were often concentrated in the hands of a few people; during the implementation of this “privatization” or, factually, snatching from personnel their part of property, the structure of organizations was changed in all cases, sometimes changed “arbitrarily”, “without idea”, “without need”, only in full conformity with the ideas of “the new owners”. In the majority of cases, the power was obviously taken by the leaders who understood “the nature of production and management” “worse than their predecessors”. Due to personal abundance and power, they had no need for a “feedback management” on the basis of professionalism and durability, and came to “dictatorship” with “unnecessary structure” of companies and work (e.g. too many vice-presidents, and frequently changing profiles of subdivisions). Power and ownership changes in companies led to differences in income, respect and authority, and also evoked a conflict between management structure and the existing production structure. The contradiction led to serious disbalance in development of the companies and entire industry branches, and expressed in voices full of anxiety by several city or region officials, journalists and public leaders in the central regions and Siberia through a number of articles and radio programs in local mass media. The discrepancy of management and production structures as well as between these structures and goals of companies aroused many problems and increased the risk of the situation getting out of control. The specific problems were “moral problems” of companies’ personnel and members of families caused by amateurish management and the feelings of loss of their part of property and voice to others, partial obsoleteness and malfunctioning of equipment so that facilities of neighbouring subdivision were often far more financed because of their higher significance in the eyes of the superiors, disparity between subdivisions leading to decrease of labour productivity, break of delivery schedule, and considerable increase of emergency risks, paradoxical derivativeness of safety and reliability matters resulting in poor financial support of safety, and increase of frequency of strikes, sometimes long-term confrontation between companies’ leaders and employees (the most colourful example was the strike of Siberian coalmine workers).

The “objective” peculiarities are considerably different in big cities and in provinces. In the former, there are such factors like high concentration of industrial plants, strong administrative or government boards, developed consumer infrastructure, and real experience of technogenic or political accidents. For the latter, these factors are not common; they have considerably lower levels of education and culture of the population, informational, educational and transport infrastructure, budgeting, equipment, transparency, higher alcoholism and environmental pollution. Most of the Russian territory and population is, however, concentrated in the provinces.

According to the majority of our respondents, the changes in both “objective” and “subjective” sphere were unsuccessful: the previously dominant traditions and stereotypes as well as risk management procedures remain alive, and the system remains inherently authoritarian. Within the framework of the new situation, the new “value and management

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conglomerate" picture has been monitored in our surveys. Two basic "value and management profiles", viz. "advanced" and "backward" companies, groups of companies, or even industries, were outlined on the basis of complex combination of five most important and statistically significant variables: (1) "serious" or "ordinary" companies (the former include state security service, nuclear power stations, space and air corporations, weapon industries, etc., while the latter include factories producing textile, footwear, food, clothes, etc.; (2) "nationalized" or "private" companies (as regards form of ownership and type of management); (3) "transparent" or "non-transparent" (style of management and existent risk assessment procedures); (4) "megalopolis" or "provincial" industries and companies (geographically and socio-culturally biased values); (5) "supported" or "not supported" by the local power authorities (advances or difficulties in supply, money, etc.) Each type is characterized by serious differences in the degree of accuracy and transparency in procedures of decision making and safety measures and works, in the degree of attention to, or neglect of "environmental" vs. "commercial" risks, in the degree of orientation toward expert or public judgements, rational approach, "flexibility", complex orientation to many vs. single aspects of the situation, and availability of safety money. (The variables for profiling "advanced" and "backward" companies were suggested by the respondents themselves through the open-end questions and reflected five most numerous criteria for "advance" and "backwardness"; the other variables were insignificant!)

It was a quite unexpected finding, that companies and industry branches in Russia correspond to mainly two contrary types regards risk management. Such a strikingly sharp distinction between "good" and "bad", "advanced" and "backward", companies was not expected a priori. Unfortunately, the number of "advanced" companies was not so great, less than 15%, vs. 85% of "backward", and almost all of them were located in large cities, excluding a few military objects still being financed by the government.

The "value and management profile" which is the commonest for potentially most risky Russian companies, i.e. those in fields of production, storage, recycling and transportation of chemical, biological and energy products, embraces the companies "ordinary", "nationalized" (or former nationalized and currently owned by thousands of shareholders), "non-transparent" (as regards decisions and management), "provincial" and "not supported". They comprise 85% of the companies and could be generally considered "backward". They are characterized by "passive" approach to risk management. Traditionally, little attention is paid to safety and risk management. For companies of this profile, lack of self-determination and unfounded optimism of risk management are common. This is a type of peculiar management infantilism which was inherited from communist ideology bravado and resulted in limited involvement in the present market economy. Leaders of companies of this profile tend to think about "production indices", but "prefer not to think about the bad". The value complexes underlying these patterns lead to apparent inability to think about risks, hazards and safety at all, to assess risks accurately; to incorrect and inaccurate risk assessments caused by lack of effective system of risk management, inability to provide complex assessments, and hence, to ineffective or even dangerous decisions. Such a profile is also characterized by a dominance

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of acute conformism of personnel's behavior, confinement to the present and inability to look into the future, ignorance of economic, mathematical, financial or other patterns, absence of general strategy of company's development and risk management. Practical assessment of possible hazards, admissible levels of risk, probabilities of possible risks and intervening factors, development of accident scenarios, and weighting costs for different scenarios, were either unknown to the majority of top management opinion givers, or they had a vague notion of these.

The other profiles are far less common. The opposite type, “ordinary” – “private” – “transparent” – “megalopolis” – “supported”, was diametrically in contrast with all of the listed features presenting the case of new progressive enterprises. These comprise 9% of the companies. They have an “active” approach to risk management, and are well-integrated into the market, managed by “smart” people, have sound relationships with local authorities and business partners, are transparent in some degree (despite “some absolutely non-transparent realms”), and have all the best and progressive possible patterns, full self-determination and well-grounded optimism and anticipation. The degree of contrast to the first profile also exceeds the one expected a priori. It is a generally “advanced” profile representing the new type of enterprises and possible directions for further improvements and development.

The third, and the last statistically significant, profile, “serious” – “nationalized” – “non-transparent” – “provincial” – “supported” constitutes 5% of the overall set of companies. It includes companies from military and related sectors characterized by “very serious” approach to risk management, specific military mentality, experienced specialists, and high level of technical equipment, despite a decrease in financial support. Based on progressive and complex patterns, they make all decisions on risk through management and assessment procedures remaining absolutely closed for the public. They are entirely supported by local authorities. These companies are definitely “advanced”, but not well-integrated into the market economy, remaining the relics of the “cold war epoch”. They are based entirely on government support and suffer from decreasing budgets for weapons and army. This is an unstable profile. Some of these companies will evolve into private companies of the second type, while some will degrade into backward companies of the first type.

CONCLUSION
In the next five to ten years, it would be possible to observe the results of further transformations in companies of two basic types, as well as those of the third type. It is obvious from the research that the most progressive value-management profile includes companies and industries having a specific market-economy-relevant profile, whereas the other profiles are not market-economy-relevant and can only hamper the changes and threaten the industry, population and environment. This “advanced” industry sector can be developed only through well-planned state policy measures, including viable reforms in ways of privatization, as a mechanism for the changes in the rest 85% of the “backward” companies. This would open new horizons of risk management and new levels of safety.

The delay of reforms in the “backward” majority of Russian companies could lead to further decay and to increase in the number of accidents with unpredictable consequences. There is

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9 The rest 1% embraces other profiles which are statistically insignificant.
10 The package of suggestions by IN-DEPTH Risk Research Group was presented for consideration to the Government of Russia.
an urgent need to stop the dominance of backward patterns, both in "objective" and "subjective" aspects of risk management\textsuperscript{11}.

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4. Feofanov K.A. Value nuances and risk management details through Germany and France (to be published).

\textsuperscript{11} The findings are especially methodologically important for the countries having large territorial area and considerable regional differences. The "abyss" between megalopolises and provinces is, however, not a necessarily precondition. Quite significant differences always exist in both industrially developed and underdeveloped countries. The methodology used by us does have peculiarities in the so-called "dwarf states", countries of little territorial extent, where regional peculiarities are expressed weakly. Even the countries traditionally considered more or less homogenous in assessing risks have valuable differences among their different parts. The results of our research in different regions of Germany and France are currently being prepared to publication. See Feofanov K.A. "Value nuances and risk management details in Germany and France" (to be published).
RISK PERCEPTION IN PORTUGAL: THE IMPORTANCE OF A MAGIC WORD

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During the last decade we have been studying the risk perception phenomena in Portugal. It was used all kind of objects (landfill, incineration and co-incineration plants, global issues, industry security) with a diverse array of subjects (engineers, school teachers, national representative surveys, population near to the sites). From those studies it was possible to conclude that, besides a general high level of risk perception, there is a interesting pattern: the importance of the word “toxic” and the central role of the landfilling process. From the data one can conclude that, when there is an attempt to build a waste treatment infrastructure in Portugal the opposition is particularly evident when we are dealing with toxic waste (versus urban waste) or when we are trying to install a landfill (versus incineration). We will present diverse types of data where we confront the perception of risk in the operation of a toxic waste landfill, toxic waste incinerator, urban incineration, and toxic waste co-incineration.

That interpretation is also corroborated by the results of the systematic comparisons between the populations near the sites and the ones more far away. From that analysis we observe what distance is necessary in order to observe a turning point (where a population starts to be positive towards an infra-structure). Those results confirm the possibility of ordering the infra-structures in risk perception and acceptance. We would explain the results applying not only the factors from the psychometric theory of risk perception but also some social and historical aspects of the Portuguese reality. It would be discussed that the high level of risk perception and high perceived insecurity from all industrial operations across the nation also imply a new reinterpretation of the NIMBY effect.
RISK BASED SYSTEM FOR MANAGEMENT OF NAVIGATION IN PORTS

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ABSTRACT
With the introduction of the Formal Safety Assessment in the International Maritime Organisation decision making process regarding new regulations, and the recent tanker disasters resulting in extensive oil pollution, the public and political pressure to improve safety in ports and the shipping industry has increased. Considering that the ports and shipping industry are at the onset of safety regimes utilised in other industries, the methodology which integrates the Safety Management System (SMS) and risk assessment has been developed. The hazard identification and the qualitative risk assessment is carried out to establish hazard barriers which are or should be in place to prevent hazards from being released; the controls for managing these hazards are then developed and integrated into the SMS. The emphasis of the approach is on the linkage between the technical and the management systems, which ensures a focused and integrated safety management.

INTRODUCTION
A number of accidents in the chemical, petrochemical and nuclear industries have, over the past decade or so, increased the public and political pressure to improve the safety which protects people and the environment. In the evolution of the approach to safety and loss prevention, it is clear that there has been an increasing move towards risk management, as opposed to more technical solutions. The reason for this evolutionary trend is simple. While design standards and technical solutions have improved, major accidents continue to occur as a function of failures in the Safety Management System (SMS). Analyses of underlying causes of failure are pointing towards the safety management and organisational practices, and not to the failure of the front line technical and human control systems. On the other hand, the main objectives of a good SMS are to provide assurance that:

- risks are identified and evaluated,
- suitable controls are in place to manage these risks,
- line management has responsibility for those tasks that ensure controls are effective at all times.

A good SMS should be tailor made for the technical system and its associated risks. To assess the technical system the following risk based methodology is applied.

Hazard Identification
The first step in scenario development is the hazard identification. At this stage we define a hazards as 'a physical situation or condition with the potential to cause harm, including injury and fatality, damage to property and/or the environment, business interruption, or increased liabilities'. Therefore, ship ‘grounding’ is considered as a possible consequence of hazards related, for example, to navigation error/failure, and not as a hazard itself. Similarly, ‘navigation’, ‘ship manoeuvring’, etc. are considered as hazardous operations because a component failure could lead to a chain of unwanted outcomes.
Hazard analysis

The hazard analysis approach which is considered suitable for ports is illustrated on a ‘bow tie’ diagram, which has been found to be an extremely useful representation of the hazard identification and risk management process, and is readily understood at all levels in an organisation. In this approach it is assumed that each specific hazard can be represented by one or several threats that have the potential to lead to an incident or top (initiating) event. A threat can be a specific hazard, or a more detailed representation of a specific hazard. Each accidental event may lead to unwanted consequences. In the example shown in Figure 1, top event is ‘pilotage error’, which can be initiated by the pilot giving an inappropriate command, or by the ship’s crew failing to execute the command. Consequences of the ‘pilotage error’ can be grounding, spillage and loss of life, Figure 2. For each threat one or several ‘barriers’ can be specified to prevent or minimise the likelihood of hazard release. The barriers to the ‘inappropriate command from a pilot’ are: ‘competent pilot’, ‘competent ship’s master’, ‘Port Control’, ‘passage plan’, and ‘navigational aids’.

For any barrier there may be internal or external factors which affect its effectiveness, for example, a competent pilot may not have been aware that the ship was a ‘bad steerer’, or he may make an ‘error of judgement’ due to being over worked. These factors or barrier failure modes can be modelled as ‘escalation factors’ each of which can be controlled by ‘escalation factor control’, Figure 1. These escalation factor controls can be envisaged as secondary barriers; for example, a ‘vessel vetting procedure’ or a ‘working hours procedure’ represent secondary barriers. Any threat should have a sufficient number of barriers and escalation factor controls to ensure the integrity of the system.

**Figure 1  Barriers, Escalation Factors and Controls**

If a hazard is released, the accidental event can escalate to one of the several possible consequences. To prevent escalation, the mitigation measures, emergency preparedness and escalation control measures need to be in place to stop chain of events propagation and/or to minimise the consequences of escalation. This is shown graphically in Figure 2, where a ‘pilotage error’ is detected and ship can be steered away from a shore (to avoid grounding), or the tugs can be used for the same purpose. Each recovery measure can be associated with one
or several failure modes, or escalation factors; for example, tug support may not be effective due to tug failure or wind and current effects. Control measures can be specified to prevent or minimise these failures. It is clear that the left and right hand sides of a bow tie correspond to fault and event trees, respectively.

**Figure 2 Recovery Preparedness Measures**

**RISK ASSESSMENT**

Risk can be qualitatively assessed by the use of a risk matrix. A typical matrix has rows representing increasing severity of consequences of a released hazard and columns representing increasing likelihood of these consequences. The matrix indicates the combinations of likelihood and consequence, and typically, there are three regions: area of broadly acceptable risk in which risk has to be managed for continuous improvement, an intermediate or tolerable region in which risks have to be reduced to a level which is as low as reasonably practicable, and an intolerable region.

In a qualitative approach such as using ‘bow ties’, it is possible to set targets for acceptance of sufficient controls being in place to meet objectives. For example, for hazards in the tolerable region the minimum requirement may be to have two independent barriers for each threat, and two independent recovery measures for each consequence, one of which must be to detect the incident, and the other to prevent further escalation.

**INTEGRATION OF RISK ANALYSIS AND SMS**

The most significant development in this approach is the integration of management activities and tasks with hazard controls, i.e. barriers, recovery measures and escalation controls. The activities and tasks taken to ensure that these controls are effective at all times are called ‘safety-critical’. Activities describe the port management system, interaction with tugs, and other stakeholders, etc. The safety-critical tasks are a subset of the management activities required for day-to-day running of the port. For this purpose each task is described along with its execution party, task inputs, task competence, methods of verification and frequency. In associating tasks with the hazard controls (barriers and recovery measures), the integrity of the management system is demonstrated. This integration of the SMS and the operating
procedures with the identified threat barriers, recovery measures, and escalation factor controls is shown schematically in Figure 3.

**FIGURE 3  AN INTEGRATED SMS MODEL**

**CONCLUSIONS**

This approach facilitates in achieving a suitable and sufficient risk assessment. A good safety management system should demonstrate that implementing measures to eliminate and/or minimise hazards and mitigate consequences has reduced risks. While it may be difficult to eliminate some hazards related to external factors, it may be possible to do so with hazards related to operations. In other words, some operations can be re-designed in such a way as to eliminate hazards from the ‘source’. A minimisation of hazards can be achieved by placing more independent barriers along a potential hazard path. By showing that all possible barriers are in place, or that there are more barriers than specified by the acceptance criteria, the principle that risk should be ‘as low as reasonably practicable’ can be demonstrated. A suitable risk assessment underpinning risk controls and defences can then be defined as fit for the purpose. The main advantage of this approach is that it is very efficient in improving safety, and is easy to communicate to personnel and the regulator. Since it ‘forces’ the management to relate management activities and tasks to hazard barriers and recovery actions, it is also a tool for day-to-day safety management.
THE ROLE OF RISK ANALYSIS IN CONTROL OF COMPLEX PLANTS' SAFETY OPERATION

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ABSTRACT
The problem of risk estimation, assessment and control is necessary to be discussed at every decision level of an activity. In this way it qualitatively assess the performances of a system, action or technology, by indicating the possible consequences on environment, people or property. The paper presents methodologies of risk assessment successful applied on isotopic separation plants. The quantitative methodologies presented, use fault tree and event tree to determine the accident states frequency, physical models to analyse the dispersion in atmosphere of dangerous substances. The qualitative methodologies use the fuzzy models for the multicriterial decision making, models based on risk matrix build on the base of combination between the severity and the probability of maximum admissible consequence. These methodologies present the following steps for applying: familiarising with the activity in study, establishing the adequate method of risk assessment, realising of the model of risk assessment foe the activity or objective in study, developing of applications of the proposed model. Applying this methodology to isotopic separation plants have conducted to: analysis of operation events and establishing of principal types of events potential dangerous, analysis of human error in these plants operation and operating experience assessment, technical specifications optimisation by probabilistic safety assessment, reliability analysis and development of reliability and exploitation events database, post accident events analysis (releases, fires, explosions) and mathematical modelling of dispersion in atmosphere of dangerous substances. The risk concept being complex and with multiple implications, is not the case of a rigid approaching neither of existence of some methods universal valuable. Because of these reasons, choosing of the most appropriate method for the risk assessment of an activity, conduct to solution in useful time, of some problems with economic, social, ecological or moral implications.

1. WHAT IS RISK?
Risk contains two essential components: the appearance frequency (probability) of a failure because an initiating event and the potential consequences on environment, people, property or financial.

A general formula for risk is:

\[ \text{Risk} = f(\text{Probability} \times \text{Consequences}) \]

Risk assessment is a process of estimating the probability of occurrence of an event and the importance of consequences for a specified period. Risk analysis is a useful method for increasing the efficiency of decision making process in safety operation of complex plants. Risk assessment methods not replace the professional judgment; instead, they evaluate, quantify and help you to understand risk so that you can design that strategy with minimum exposure to risk.
2. QUANTIFYING RISK

The risk quantification of a dangerous potential activity can be quantitatively or/and qualitatively, through probability approach or/and fuzzy logic approach. The probability is based on the statistics of a large number of experimental results concerning the events or similar events.

Fuzzy numbers are represented by a set of elements X and its associated membership function \( x \), through that for each element \( x \in X \) it associated a value \( x(x) \in [0, 1] \), which characterized the membership degree of \( x \) to X.

3. RISK ANALYSIS METHODS

Generally, there are three different approaches are used in risk based decision process: the decision tree analysis, the stochastic simulation and analysis methods based on fuzzy logic. The application of these three methods is based on the complexity of the problem. The tree analysis is used for sequential decision making processes and it used in cases in which the events and achievement probabilities are already known. In some cases, the anticipated outcomes depend on several input variables whose values may not be exactly known. These kinds of problems are usually analyzed by stochastic simulation methods, such as a Monte Carlo simulation.

In the complex systems cases, the conventional quantitative techniques for risk assessment are sometimes hard to use or even impossible, when the data are briefly and vague. Then it resorts to unconventional techniques based on fuzzy logic.

4. ANALYSIS OF RISK IN THE ISOTOPIC SEPARATION PLANTS

The isotopic separation plants are complex plants, for example: heavy water upgrader plant, heavy water detritiation plant, and ultradistilled water plant. They are characterized by handling and spreading of dangerous materials, which after an accident can be released in atmosphere, so affecting the environment, the people and the property.

The risk analysis for isotopic separation plants it achieves by both qualitative methods, when the data are summary and vague and by quantitative methods, when statistical data regarding similar events are available.

By the applying of preliminary hazard analysis, FMEA, HAZOP studies, it settles the main types of potential dangerous events are settled.

In the case of summary and vague data, by the using of fuzzy methods for multicriterial decisions and of conventional score it determine the risk level for each event is determined.

In other cases, the risk is analysed using the event trees, which includes the fault trees that describe the role of security systems that have the role of consequences' mitigation.

The fault trees are qualitatively assessed by Boolean minimisation and quantitatively by probabilistic assessment of systems’ components’ reliability and human performance.
The fault trees integration in the event trees conduct to the appearance frequencies (probabilities) of the accident states and the settlement of basic events' contribution to the accident occurring. These methods follow the steps: familiarising with the activity or objective for study, settle the adequate method for risk analysis function of complexity and available data, achieving the model of risk assessment and applications development of the proposed model.

In the figure 1 is presented an example of calculus for the event tree: "massive loss of liquefied gas from a tank"

<table>
<thead>
<tr>
<th>Massive loss of liquefied gas</th>
<th>Immediate firing</th>
<th>Wind towards the populated area</th>
<th>Late firing</th>
<th>Vapor cloud explosion (VCE) or fire caused by a spark</th>
<th>Jet firing near the liquefied gas tank</th>
<th>Result</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (0,1)</td>
<td></td>
<td>Yes (0,15)</td>
<td>Yes (0,9)</td>
<td>Yes (0,2)</td>
<td>No (0,8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 x 10^-4/year</td>
<td></td>
<td>No (0,9)</td>
<td>No (0,5)</td>
<td>Yes (0,2)</td>
<td>No (0,8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No (0,1)</td>
<td>No (0,5)</td>
<td>No (0,8)</td>
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<tr>
<td></td>
<td></td>
<td>No (0,1)</td>
<td>No (0,5)</td>
<td>Yes (0,2)</td>
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<tr>
<td></td>
<td></td>
<td>No (0,1)</td>
<td>Yes (0,9)</td>
<td>Yes (0,2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No (0,85)</td>
<td>No (0,5)</td>
<td>No (0,8)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>No (0,1)</td>
<td>No (0,5)</td>
<td>No (0,8)</td>
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</tbody>
</table>

Fig. 1. Example of event tree calculus

The applying of unconventional techniques based on fuzzy logic is exemplified on a heavy water plant, presented in figure 2 /3,4/.

Fig. 2 Prioritisation of the potential dangerous events
5. CONCLUSIONS
The applying of risk analysis methods to the isotopic separation plant supplied information for: the analysis of operation events and the settlement of the main types of potential dangerous events, the human error analysis and operation experience assessment, the technical specifications optimisation by probabilistic safety assessment, the reliability and operation events database, the analysis of post-accident events (releases, fire, explosion) and mathematical modelling of dispersion in atmosphere of dangerous materials.

REFERENCES
INDUSTRIAL RISK MANAGEMENT IN ECOLOGICAL INSURANCE

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Tel/Fax: +095 332 4224

Risk is a “two-dimensional value” that includes both the possibility of an accident and its consequences.

In order to diagnose potential danger to human health and environment we have developed special methods of creating a mechanism of industrial risk management by estimating economic effects of toxic substances influence the environment.

Development of an mechanism of industrial risk management consists of the two stages: creation of new or development of already existing technical devices reducing toxic substances influence upon the environment and development of administrative and economic system that would encourage the enterprises to reduce their influence upon the environment.

Risk management and minimizing the possibility of environment pollution require determining the prior investment fields in order to reduce the risk to an appropriate level. Risk management must be based on balancing the investment in reducing the risk and the results of it which are represented by reducing the risk and in the long run cutting it down to an appropriate level.

From 1994 through 1997 there was an experiment on risk insurance development conducted in Russia during which the criteria of ecological danger of enterprises were developed and economic principle of risk management were brought to life.

By now “The governmental program of ecological risk insurance and chemical safety in Russia” has been worked out which includes trying the mechanism of industrial risk management in ecological risks insurance developed in the Institute for Market Economy Problems of Russian Academy of Sciences.
IMPROVEMENT OF RISK ANALYSIS METHODS FOR EVALUATION OF DANGEROUS ENTERPRISES

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According to the worldwide downdrift of dangerousness of industrial activities, which foundations were laid by Sevezo directive 1982, in Russia July 1997 the Law “Industrial Safety of Dangerous Enterprises” was adopted, under which administrations of plants must declare all possible dangers associated with the activity. Therefore the development of danger evaluation methods has been intensively developing. Scientific foundation for working out the Enterprise Safety Declaration is the risk analysis method.

Within the framework of this study we performed the procedure of risk analysis for Zaikinsky refinery project (Orenburg region, Southeast of Russia) accordingly to the technique developed by GazProm Co. and Chair of Chemical Technology, the outline of which is represented in the table 1. Zaikinsky refinery should enable to solve the following tasks: oil gases compression and processing into liquefied hydrocarbon gases, oil stabilisation, processing of oil (500000 tones per year) into petrol and diesel fuel.

Study of technological description of Zaikinsky refinery leads to a conclusion that the refinery may be divided into three main technological units, in which accidents may cause serious wreaking for staff and for the equipment, corresponding to the type of process, the type of processed substance and most probable type of accident.

Table 1. Main steps of risk analysis procedure (by Gazprom Co. and Chair of Chem. Technology MSU).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Basing the objectives of risk analysis</td>
</tr>
<tr>
<td>2.</td>
<td>Analysis of technological description of an enterprise. Identification of potential dangers and classification of undesirable events, which can cause discharges of rapid energy releases</td>
</tr>
<tr>
<td>3.</td>
<td>Determining of undesirable events frequency</td>
</tr>
<tr>
<td>4.</td>
<td>Detailing of characteristic peculiarities, determining of the intensities, total amounts and duration of discharges of energy releases in environment for all range of undesirable events</td>
</tr>
<tr>
<td>5.</td>
<td>Determining of leisure criteria and permissible levels of single or permanent adverse exposure of different sources on the environment (“risk groups”)</td>
</tr>
<tr>
<td>6.</td>
<td>Basing of physical-mathematical models and calculation of spatial and temporal transference and distribution, and the transformations of initial dangers in the environment (taking into account local climatic and geographical specific character)</td>
</tr>
<tr>
<td>7.</td>
<td>Determining of the potential risk fields around each of marked danger sources, within which a stated adverse exposure on correspondence objects may take place</td>
</tr>
<tr>
<td>8.</td>
<td>Calculation of direct and indirect consequences of the exposure on objects or risk groups taking into account its quantitative and spatial-temporal distribution around danger sources</td>
</tr>
<tr>
<td>10.</td>
<td>Development of remediation measures for reducing of risk up to necessary level</td>
</tr>
</tbody>
</table>
The first unit is $\text{CH}_4$ processing, the second one is $\text{C}_2\text{H}_6$, $\text{C}_3\text{H}_8$ and $\text{C}_4\text{H}_{10}$ processing and the third one is oil processing and keeping. The main types of accident scenarios are the fires, BLEVEs, explosions of steam clouds, jet flames under depressurising of the equipment and ignition of high-speed jets of hydrocarbons. Its final results are presented in the figure 1, that shows the spatial individual risk distribution within the area of Zaikinsky Refinery. The magnitudes of total risk values of each constituent technological unit are following:

- Natural gas ($\text{CH}_4$) processing: $9,7 \times 10^{-4}$ death-year$^{-1}$
- Liquefied gases ($\text{C}_2\text{H}_6$, $\text{C}_3\text{H}_8$, $\text{C}_4\text{H}_8$) processing: $6,2 \times 10^{-4}$ death-year$^{-1}$
- Oil processing and storing: $24,0 \times 10^{-4}$ death-year$^{-1}$

Since the constituent technological units may be distinguished each other by specific setting of compounds (with specific physical-chemical properties) we wondered whether the danger assessment associated with the chemical properties would give similar results. Therefore we conducted the evaluation of danger with the help of the fast evaluation technique of danger by physical-chemical properties of processed substances their parameters of inflammability.
Table 2. The layout of fast evaluation technique of danger by physical-chemical properties of inflammability.

<table>
<thead>
<tr>
<th>PHYSICAL-CHEMICAL PROPERTY “A_C mh”</th>
<th>RELATIVE DANGER FACTOR $K_{A_C mh}$ OF HYDROCARBON $C_nH_m$ CORRESPONDING TO THE PARAMETER “A_C mh”</th>
<th>TOTAL RELATIVE DANGER FACTOR $K_{C, C mh}$</th>
<th>RELATIVE TOTAL DANGER OF TECHNOLOGICAL UNIT $RTD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ST STEP</td>
<td>2ND STEP</td>
<td>3RD STEP</td>
<td>4TH STEP</td>
</tr>
<tr>
<td>$t_c$ - Temperature of self-ignition</td>
<td>$K_t = 151.3 - 0.233 \cdot t_c$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$w_{min}$ - Minimal energy of inflammability</td>
<td>$K_w = 106.2,3 - 366.5 \cdot w_{min}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Pi_a$ - Highest concentration of inflammability</td>
<td>$K_{\Pi} = 102 - 6.8 \cdot \Pi_a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Pi_n$ - Lowest concentration of inflammability</td>
<td>$K_{\Pi} = 102.4 \cdot (\Pi_a - \Pi_n) - 0.4$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$U_n$ - Normal speed of mixture burning</td>
<td>$K_u = 303 \cdot U_n - 90.9$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_a$ - Explosion pressure</td>
<td>$K_p = 0.575 \cdot P_a - 345$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$G$ - Rapidity of evaporation</td>
<td>$K_G = 41.911 \cdot G - 6.709$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m$ - Rapidity of burning on the surface</td>
<td>$K_m = 649.35 \cdot m - 9.74$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table 2 shows its layout. The first step of the procedure is to find magnitudes of main inflammability parameters of processed substances (by the using of reference books). They are listed in the left bar of table 2. By the values of inflammability parameters each processed substance may be characterised with factor of relative hazard. The least dangerous substance has zero value of the factor and the most dangerous has 100 value. For example, in a case of low concentration limit of ignition zero is imputed by NH$_3$, and 100 by ethylene oxide. Then in order to compare hydrocarbons by their inflammability they were characterised by a united parameter - factor of total relative danger $K_{C, C mh}$. The table 3 represents the relative hazard coefficients and the total relative hazard coefficients. It’s apparent that the methane is a less dangerous kind of fuel then petrol, liquefied hydrocarbons and all the more in comparison with hydrogen.

Further the product of total relative danger factor of substance and its mass can be used for characterising of relative danger of the given production. These parameters of relative danger for chosen technological blocks are:

Natural gas (CH$_4$) processing: 2,16
Liquefied gas (C$_2$H$_6$, C$_3$H$_8$, C$_4$H$_{10}$) processing: 0,189
Oil processing and keeping: 0,4

To examine whether the agreement between the values obtained by both the methods exists the diagram was made (fig.2). It shows that the correspondence between parameters of relative danger of main technological blocks and magnitudes of total risk exists.
Table 3. Factors of relative hazard and total relative hazard.

<table>
<thead>
<tr>
<th>Danger factors</th>
<th>Methane</th>
<th>Ethane</th>
<th>Propane</th>
<th>n-Butane</th>
<th>Hydrogen</th>
<th>Petrol B-70</th>
<th>Fuel-1</th>
<th>Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kt</td>
<td>32,5</td>
<td>41,3</td>
<td>42,7</td>
<td>56,9</td>
<td>26,2</td>
<td>45</td>
<td>100</td>
<td>81,4</td>
</tr>
<tr>
<td>Kn</td>
<td>65</td>
<td>18,3</td>
<td>10,9</td>
<td>10,9</td>
<td>100</td>
<td>51,2</td>
<td>93,8</td>
<td></td>
</tr>
<tr>
<td>KA</td>
<td>66</td>
<td>81,6</td>
<td>87</td>
<td>89,1</td>
<td>74,8</td>
<td>94,7</td>
<td>93,8</td>
<td></td>
</tr>
<tr>
<td>KC</td>
<td>38,7</td>
<td>49,0</td>
<td>45,3</td>
<td>38,7</td>
<td>100</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KB</td>
<td>2,95</td>
<td>5,1</td>
<td>5,1</td>
<td>100</td>
<td>5,9</td>
<td>13,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kp</td>
<td>61</td>
<td>83</td>
<td>90</td>
<td>94</td>
<td>71</td>
<td>95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KG</td>
<td>48,8</td>
<td>32,5</td>
<td>18,8</td>
<td>2,5</td>
<td>100</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Km</td>
<td>40,9</td>
<td>55,2</td>
<td>40,9</td>
<td>100</td>
<td>21,4</td>
<td>13,0</td>
<td>15,6</td>
<td></td>
</tr>
<tr>
<td>KL</td>
<td>364</td>
<td>459</td>
<td>438</td>
<td>755</td>
<td>465</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kc/Kc'1/112</td>
<td>1,0</td>
<td>1,26</td>
<td>1,20</td>
<td>2,04</td>
<td>1,28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thus we may conclude that approach proposed may be applied at the first step of working out Safety Declaration of similar productions for selection of the most dangerous constituent technological unit. Further action would be comprehensive risk assessment of the defined most dangerous technological unit accordingly to the first technique. Narrowing of number of enterprise units to be chosen for risk analysis enables us to reduce the time and efforts for carrying out of risk analysis procedure full out. As well the results allows us to make a conclusion that the obtained data might be very useful information for prioritization of risk minimisation efforts and that further development of such techniques is reasonable.

Fig. 2 Comparison of results obtained by means of GazProm and Chemical properties techniques.
ACCIDENT REPORTING SYSTEM DEVOTED TO SMALL COMPANIES

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Although small companies in France employ two-third of manpower and suffer the greatest number of occupational accidents, very few Health and Safety studies have been developed in this area. In particular methods of risk analysis have to be used by companies to be in accordance with regulation. Such methods exist but their use require some knowledge of typical accident scenarios as well as data about frequency and gravity rates of incidents. The concept developed in this article is that a reporting system may provide this information. Among examples of existing systems, a network of small companies with a central organisation seems to be the most suitable organisation for the reporting system. It would provide a preexisting database designed for risk analysis, that the companies could enrich with their own experience.

INTRODUCTION
As far as safety is concerned, small companies are nearly a virgin field. They are numerous and have high accident frequency rates. In France, regulation has strengthened and small companies now have to carry out risk analysis. Some methods exist for this purpose but they need to be fed with data to be applied. Reporting system may be used to make those data available to small companies. This article presents the basics of an accident reporting system devoted to help small companies to carry risk analysis easily out.

1. LEARNING LESSONS FROM EXPERIENCE FOR RISK MANAGEMENT
Learning lessons from experience is a very old concept. For companies, it means assessing past successes and failures, and introducing learnt lessons into the company's expertise in order to assure successes and to avoid failures in the future[1]. In the field of safety, this idea is linked both to a posteriori accident assessment methods and to broader tools aiming to detect, assess, archive and correlate all the precursors and all failures even if they seem to be insignificant[2]. Charles Perrow and Barry Turner developed the organisational approach as opposed to the individualistic approach to the human factor. In the organisational accident model, events do not occur more or less suddenly, being triggered by an initiating event (technical failure or human error), but develop slowly, often over several years. Events are preceded by an incubation period, which makes correction all the more possible, thereby improving prevention, on condition, however, that the "weak signals" foreshadowing more serious events can be identified [3].

Reporting systems allow to implement this concept into very different ways. Numerous seminars have recently been devoted to them. At the French level, the Centre National de la Recherche Scientifique (CNRS) organised in 1998/1999 a series of seminars which allowed representatives of various organisations to discuss their reporting systems [4]. At the European level, the European Safety Reliability & Data Association (ESReDA) organised in 1998 the "Accident Databases as a Management Tool" seminar, which clearly focused on databases, favoured medium of reporting system, and management. Management systems rely on continuous improvement, a process that is similar to learning lessons from experience. Safety management systems are increasingly considered both through regulation (with the SEVESO II directive) and standards.
2. FEATURES OF REPORTING SYSTEMS

2.1 Objectives

The collection and storage of accident data is not intrinsically valuable. To be useful, databases must be explicitly designed to assist the users in their own approach. The main objectives of accident databases that ESReDA defined are the identification of accident scenarios and of deficiencies in design of operation of hazardous installations and hazardous systems, the improvement of total quality management of safety and the establishment of reliability and failure rates [5]. Organisations which have reporting system are generally heading towards a "pro-active culture" in which organisations "act before the fact" and take own initiative based on knowledge, information and analytical tools in the development of their safety management systems. On the other hand, small companies have often a "compliance culture" in which designing and acting by the rules is regarded sufficient, and the main objective seems to avoid problems with authorities and others parties [6]. However risk analysis has become a legal requirement. The different steps of risk analysis are:

- Identification of undesired events
- Evaluation of the probability and their consequences of these events
- Development of prevention and protection measures
- Control of the implementation of the risk reduction measures [7].

A reporting system finds an application in the first two steps of risk analysis by providing the basic elements for risk identification and risk evaluation. It is thus useful to both types of companies: those having a pro-active culture, which integrate the reporting system as part of their management system, and those having a compliance culture, which have to perform risk analysis anyway.

2.2 Structure

The different systems have roughly the same layout. They usually are composed of:

- a notification and reporting system,
- a review-system for the assessment for validity of notified incidents and applied interventions,
- a system to store and retrieve-on-demand potentially successful interventions for an occurring abnormal situation,
- a systemic causal factor analysis system [8].

From the causal analysis some measures of prevention or protection can be defined and forwarded to the other components of the system.

But, the lack of means, time, training and structure characterises small companies and compromises the implementation of such a tool [9]. However, such a system is not necessarily settled in a single company. Among the examples of the ESReDA seminar, many situations can be found, such as:

- an accident database at a national level in Finland as a supervision tool of the authority [10],
- an observatory of incidents and accidents at an international level and concerning different types of industries, which, in particular, raises the problem of the relevance of the information to companies different from the company which provided the data [3],
- the use of a preexisting database, completed by users [11],
- the concept of the "Störfall-Kommission" of the Federal Republic of Germany for the registration and evaluation of safety-relevant industrial incidents, where a notification office centralises information and prepares a short report, made anonymous, for the Kommission who analyses the reports and elaborates recommendations [12].
These examples show the interest of a network-based reporting system. As far as small companies are concerned, the implementation and initial filling of a reporting system requires too much time and energy. Operating though a network that would provide the database structure and make the initial filling data available seems much more suitable for small companies. In the next part of this article, a network based reporting system dedicated to small manufacturing companies, presently developed at the ENSMSE, is briefly described.

2.3 Human factor

Human factor takes an important part in reporting system because of the necessary motivation of the staff to notify incidents despite the persistent notion of fault. Ringstad describes the psychology of accident reporting system for big organisations [13]. In particular, he identified two schools of thought in the understanding of the causes of accidents: high reliability theory and normal accident theory. High reliability theory has an optimistic view on the possibility to avoid accidents by systematic safety management and proper organisational design. The normal accident theory, on the other hand, considers that accidents are inevitable. The small companies not only tend to follow the normal accident theory but have particular relationships with safety because of the size of the staff. A sociological study by Eakin [9] devoted to prevention in small companies was realised with fifty independent companies employing less than forty persons in different branches of industry. According to this study, managers tend to consider health and safety as being question of personal values rather than professional duties. So they often dislike intervening in these areas because it can be considered as too much intrusive. This particular perception of risk by small companies must be taken into account in the design of an accident reporting system. Eakin suggests to restore the prominent role of the rule, as it moves health and safety from the "moral" field toward the "bureaucratic" one [9]. A tool could allow to unpersonalize the prevention, rationalising and formalising the decision-making.

3. ACCIDENT REPORTING SYSTEM DEVOTED TO SMALL COMPANIES

3.1 A network based system

A reporting system is presently being developed at the ENSMSE. It will be used in small companies in the field of the mechanical industry with the purpose to help them in undertaking risk analysis. To avoid the difficulties mentioned before, this system will be based on a network headed by a central organisation such as a "centre technique" or the "fédération des industries mécaniques". The central organisation will first provide the basic data on process, product, tool or regulation. Then it will collect information on accidents of small companies, which accept to belong to the network, and redistribute the information hiding the company's identity in order to complement the database.

3.2 Structure of the reporting system

The database will be structured so as to help to perform a risk analysis. A collaboration is presently studied with the CETIM, which is the French organisation gathering the companies of the mechanical industry sector and having an advising function. This collaboration will allow to test the concept with few companies. The contribution of the database to the different steps of the risk analysis is the following:

a) Identification of undesired events: the plant is broken up into component parts either on geographical or functional criteria. Each component is characterised by keywords in the database and combined with risks.

b) Evaluation of the probability and consequences of undesired events: a difficulty related to risks of small companies is that an event can generally not be associated with a quantitative
probability or gravity value. At best it can be set in a quantitative or qualitative class of frequency. The classical breaking down in elementary events can nevertheless be done and the accident assessment may provide the most frequent elementary events. Then the database can propose their list. In the same manner, it can provide the list of the main kind of consequences and their indicators (cost, injury, etc.) and so an estimation of the gravity scale. The aim of these evaluations is comparing the risks to each other. Therefore an accurate value is not needed.

c) Development of prevention and protection measures: the database may provide a list of advisable measures, progressively completed with actual measures taken to prevent accidents in companies of the network.

d) Control of the implementation of the risk reduction measures: the database may help companies to evaluate the efficiency of their risk prevention measures by following the behaviours of indicators such as the number of different elementary events.

3.3 Structure of the database
Two kinds of accesses to the database, presently under study, have to be distinguished: entering accident data and performing risk analysis. In the first case, the user is guided by questions based on methods such as Fault Tree or Ishikawa's graph. The information is organised in the database following the principle of the hierarchical indexing developed at Loughborough University [14]. This way of indexing is an alternative system compared to traditional alphabetically organised keywords. Hierarchical indexing allows, because of data organisation, to file accidents report in a logical manner, and so to retrieve with much chance all appropriate and no inappropriate information. The classification hierarchies chosen for the present database, represent respectively, the geographical or functional areas, the hazardous equipment and operational activity, the accident events, their causes and consequences. The user is directed towards these hierarchies to enter accident data. In the second case, the succession of screens guides the user through the different steps of risk analysis. The tool provides information about accident reports, regulation, techniques and statistics, organised according to the hierarchical indexing described above. The statistics concern, for instance, the elementary events which composed accident scenarios, and their causes and consequences. Their aim is twofold, to give an estimation of probability of elementary events and to help to identify systemic causal factors.

CONCLUSION
A reporting system aimed to assist small companies in undertaking risk analysis, is under study at ENSMSE. Inspired by various existing reporting systems developed in different contexts, a network of small companies with a central organisation seems to be the most suitable structure for our purposes. A database with basic information will be provided by the central organisation and complemented by data about accidents of the small companies which belong to the network. The database will be structured using hierarchical indexing to make the retrieval of information easier and will propose a succession of screens guiding the user through the different steps of risk analysis.

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TRACK 2

SESSION 6

METHODS FOR ECOLOGICAL/ENVIRONMENTAL RISKS
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Risk Analysis: Facing the New Millennium

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[4] H.A. WIE, Some suggestions for a management tool to⒞medium and small-sized
even, 12th ESNM Seminar "Managing Databases as a Management Tool", Aix-en-Provence (Fr), November 16-17, 1993.


IDENTIFYING THE KEY PARAMETERS IN EXPOSURE ASSESSMENT USING PROBABILISTIC SENSITIVITY ANALYSIS

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ABSTRACT
Probabilistic sensitivity analysis was used to identify the most sensitive exposure parameters for further parameter refinement at a contaminated site. The incremental lifetime cancer risk (ILCR) following arsenic exposure due to inhalation of particulates and ingestion of soil ranged from $3.5 \times 10^{-3}$ to $1.9 \times 10^{-7}$ with the mean of $1.4 \times 10^{-4}$. The point estimate for the risk ($2.2 \times 10^{-4}$) falls at the 82nd percentile in the probabilistic range of risk. Effect of parameter uncertainty to the location of resulting distribution was tested for different parameter groups. Parameters were grouped according to the shape of their distribution and location of the point estimate. Group B parameters resulted the most dramatical spread in the output distribution. Group B and, therefore, overall uncertainty was dominated by the arsenic concentration in the soil.

METHODS
Exposure assessment was made for a former wood impregnation site. The treatment site operated from 1952 till 1978 and soil contamination resulted from the use of chromated copper arsenate (CCA). Nearby residences are located 50 m from the site boundaries. There are no future plans for the site, therefore exposure is limited to the nearby residents and possible trespassers. For the purpose of this study, only arsenic exposure by inhalation of particles and ingestion of soil was evaluated. Incremental lifetime cancer risks ($\text{ILCR}_{\text{inh}}$, inhalation of particulates, $\text{ILCR}_{\text{ing}}$, ingestion of soil, $\text{ILCR}_{\text{cp}}$, ingestion of particulates) were calculated by the following equations, adapted from U.S. EPA guidelines (1). Total risk was calculated by summing the pathway specific risks.

$$\text{ILCR}_{\text{inh}} = \text{CSF}_{\text{inh}} \times B_0 \times \left( \sum_{i=0}^{n} \left( \frac{\text{IRS}_i}{\text{BW}_i} \times \frac{1}{10} \times \text{US} \times \text{FE} \times \text{ED}_i \right) + \left( \frac{\text{IR}_{\text{PM}_{10}}}{\text{BW}_0} \times \text{ED} \right) \right) \times \text{CS} \times \text{CFS} \times \frac{1}{\text{AT}}$$

$$\text{ILCR}_{\text{ing}} = \text{CSF}_{\text{ing}} \times B_0 \times \frac{\text{FR}}{10} \times \left( \sum_{i=0}^{n} \left( \frac{\text{IRA}_i}{\text{BW}_i} \times \frac{1}{10} \times \text{ED}_i \right) + \left( \frac{\text{IR}_{\text{PM}_{10}}}{\text{BW}_0} \times \text{ED} \right) \right) \times \frac{\text{CP} \times \text{CS} \times \text{CFA} \times \text{US} \times [\text{ET}_{\text{out}} + (\text{ET}_{\text{in}} \times \text{IDF})] \times \frac{1}{\text{AT}}}{\text{AT}}$$

$$\text{ILCR}_{\text{cp}} = \text{CSF}_{\text{cp}} \times B_0 \times \frac{\text{FRI}}{10} \times \left( \sum_{i=0}^{n} \left( \frac{\text{IRA}_i}{\text{BW}_i} \times \frac{1}{10} \times \text{ED}_i \right) + \left( \frac{\text{IR}_{\text{PM}_{10}}}{\text{BW}_0} \times \text{ED} \right) \right) \times \frac{\text{CP} \times \text{CS} \times \text{CFA} \times \text{US} \times [\text{ET}_{\text{out}} + (\text{ET}_{\text{in}} \times \text{IDF})] \times \frac{1}{\text{AT}}}{\text{AT}}$$

Where, CSF is the cancer slope factor (kg×day/mg), B is the bioavailability, IRS is the soil ingestion rate (mg/day), BW is the body weight (kg), ED is the exposure duration (years), US is the amount of days when the soil is unfrozen (days/year), FE is the fraction of unfrozen days when exposure happens, CS is the arsenic concentration in the top soil (mg/kg), EF is the exposure frequency (days/year), CFS is conversion factor ($10^{-6}$ kg/mg), AT is the averaging time (days), FR is the fraction of inspired particulate absorbed in lower respiratory tract, FRI is the fraction of inspired particulates ingested, IRA is the inhalation rate (m$^3$/h), CP is the particulate (PM$_{10}$) concentration in the air (μg/m$^3$), FS is the proportion of particulates attributed to the site soil, CFA is conversion factor ($10^{-9}$ kg/μg), ET$_{\text{out}}$ is the outdoor exposure time (h/day), ET$_{\text{in}}$ is the indoor exposure time (h/day), IDF is the proportion of indoor dust.
attributable to outdoors. Subscript 0 denotes oral, i inhalation, s soil, p particles, c children, and a adult. Input parameters are shown in Table 1. Carcinogenic slope factors were entered as point values, so their effect on variability in the risk estimate was not estimated.

Table 1. Variables and constants used in risk assessment of a contaminated site.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Point estimate</th>
<th>Distribution parameters</th>
<th>Distribution type</th>
<th>Point estimate location</th>
<th>Group</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSF&lt;sub&gt;1&lt;/sub&gt;</td>
<td>(kg/day/mg)</td>
<td>15.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CSF&lt;sub&gt;2&lt;/sub&gt;</td>
<td>(kg/day/mg)</td>
<td>1.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>B&lt;sub&gt;in&lt;/sub&gt;</td>
<td>-</td>
<td>0.45</td>
<td>Min = 0.3 Max = 0.6</td>
<td>U</td>
<td>Median</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B&lt;sub&gt;out&lt;/sub&gt;</td>
<td>-</td>
<td>0.50</td>
<td>Min = 0.15 Max = 0.85</td>
<td>TR</td>
<td>Median</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>FR</td>
<td>-</td>
<td>0.33</td>
<td>Min = 0.2 Max = 0.33</td>
<td>U</td>
<td>Max</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>FRI</td>
<td>-</td>
<td>0.67</td>
<td>Min = 0.58 Max = 0.67</td>
<td>U</td>
<td>Max</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>µg/m³</td>
<td>20</td>
<td>µ = 20 σ = 12</td>
<td>LN</td>
<td>Mean</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>mg/kg</td>
<td>395.8</td>
<td>Loc = 2.69 Scale = 318.7</td>
<td>W</td>
<td>Mean</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>-</td>
<td>0.50</td>
<td>Min = 0.15 Max = 0.5</td>
<td>U</td>
<td>Max</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>IRA</td>
<td>m³/day</td>
<td>8.7 (1-12 yrs)&lt;sup&gt;(11)&lt;/sup&gt;</td>
<td>3.3 (5%) 6.7 (95%)</td>
<td>Max</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRS</td>
<td>mg/day</td>
<td>152 (adult&lt;sup&gt;(11)&lt;/sup&gt;)</td>
<td>6.1 (5%) 11.8 (95%)</td>
<td>45&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW</td>
<td>kg</td>
<td>11.8</td>
<td>µ = 11.8 σ = 1.9</td>
<td>Mean</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET&lt;sub&gt;inc&lt;/sub&gt;</td>
<td>min/day</td>
<td>120</td>
<td>105 (50%) 362 (90%)</td>
<td>U</td>
<td>52&lt;sup&gt;nd&lt;/sup&gt; percentile</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>ET&lt;sub&gt;in&lt;/sub&gt;</td>
<td>h/day</td>
<td>16.4</td>
<td>16.4 (50%) 23.3 (90%)</td>
<td>U</td>
<td>Median</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>days/year</td>
<td>215</td>
<td>Min = 142 Max = 355</td>
<td>TR</td>
<td>24&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>FE</td>
<td>-</td>
<td>1</td>
<td>Min = 0.2 Max = 1</td>
<td>U</td>
<td>Max</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>EF&lt;sub&gt;a&lt;/sub&gt;</td>
<td>days/year</td>
<td>40</td>
<td>Min = 20 Max = 60</td>
<td>U</td>
<td>Median</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>ED</td>
<td>years</td>
<td>Adult&lt;sup&gt;(11)&lt;/sup&gt;</td>
<td>g&lt;sup&gt;(11)&lt;/sup&gt;</td>
<td>Min = 1.4 Max = 41.4</td>
<td>U</td>
<td>19&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>D</td>
</tr>
<tr>
<td>AT</td>
<td>years</td>
<td>Child&lt;sup&gt;(11)&lt;/sup&gt;</td>
<td>g&lt;sup&gt;(11)&lt;/sup&gt;</td>
<td>Min = 1.4 Max = 10</td>
<td>U</td>
<td>88&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>C</td>
</tr>
<tr>
<td>ED</td>
<td>years</td>
<td>75</td>
<td>Min = 73 Max = 79.5</td>
<td>U</td>
<td>31&lt;sup&gt;st&lt;/sup&gt; percentile</td>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Overall mean daily soil ingestion, not projected over a period of 365 days.
<sup>b</sup> 480 mg/day while engaged in yardwork

µ, mean; σ, standard deviation; LN, lognormal; W, weibull; U, uniform; TR, triangular

A negative correlation of -0.5 was assumed to represent the possible correlation between childhood and adulthood exposure duration. Exposure was calculated for age groups 0 to 3, 4 to 10 and over 10 years. Exposure parameters were approximated by probability distributions found from the literature. Distribution type for arsenic concentration data was evaluated using D’Agostino’s test<sup>(15)</sup> and Kolmogorov-Smirnov goodness-of-fit test. Probabilistic calculations were done by Monte Carlo simulation with Latin Hypercube sampling (LHS) using Crystal Ball<sup>®</sup> 4.0 spreadsheet program<sup>(16)</sup>. Effect of parameter uncertainty to the location of resulting distribution was tested for different parameter groups by freezing all other parameters to their nominal values. Parameters were grouped according to the shape of their distribution and location of the point estimate. Group A parameters have symmetric distributions, and their point estimates are near the mean. Group B parameters have asymmetric distributions and point estimates near the mean. Group C parameters have symmetric distributions with point
estimates above the mean and Group D parameters have asymmetric distributions and point estimates below the mean.

RESULTS AND DISCUSSION
A Latin Hypercube sampling with 10 000 iterations resulted a ILCR ranging from $3.5 \times 10^{-3}$ to $1.9 \times 10^{-7}$ with the mean of $1.4 \times 10^{-4}$ and standard deviation of $2.2 \times 10^{-4}$. Kolmogorov-Smirnov goodness-of-fit test gave the best fit for the ILCR distribution with Weibull distribution ($\text{Loc} = -5.9 \times 10^{-8}$, $\text{Scale} = 1.4 \times 10^{-4}$, $\text{Shape} = 0.67$). The point estimate for the risk ($2.2 \times 10^{-4}$) falls at the 82nd percentile in the probabilistic range of risk. The probability distribution of ILCR is shown in Figure 1.

![Figure 1. Probability distribution of incremental lifetime cancer risk (ILCR).](image)

Probabilistic sensitivity analysis indicated that group B and C parameters shifted the distribution toward values lower than the point estimate. The width of the output distribution with group B was 10 times the width with the other groups. Also, the coefficient of variation was one fold higher than with other groups. The point estimate shifted to 60th percentile. Group C shifted the point estimate to the 79th percentile, but the distribution was narrower than with group B. Group A caused almost symmetrical spread around the point estimate, which falls at the 49th percentile. Group D parameters shifted the distribution to values higher than the point estimate, which shifted to the 16th percentile. Probabilistic sensitivity analysis

![Figure 2. Probability distributions of ILCR using group A, B, D and D random variables while other parameters are kept at their nominal values.](image)
was redone for group B parameters because of the spread caused to the output distribution and the highest coefficient of variation. Arsenic concentration in soil as a random variable resulted the widest range and also had the highest coefficient of variation, and was therefore assumed to dominate the variability within group B and as a consequence, the overall variability. Resulting probability distributions for ILCR are shown in Figure 2.

Parameters having the greatest impact on ILCR were also identified by rank correlation coefficients with the Crystall Ball program. The most important parameter was the arsenic concentration in soil (CS) (rank correlation +0.94 equals 91.4% contribution to the overall uncertainty). The contribution of the other parameters to the overall uncertainty was less than 5%. Overall uncertainty seemed to be dominated by the uncertainty in arsenic soil concentration data. This agrees with the result of probabilistic sensitivity analysis with the parameter groups. Reducing the uncertainty of the soil concentration data could reduce the uncertainty in this assessment.

REFERENCES
THE DEVELOPMENT OF RISK ASSESSMENT CAPABILITIES
WITHIN THE ENVIRONMENT AGENCY

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11 Tothill Street, London SWIH 9NF

ABSTRACT
The Environment Agency has responsibilities in England and Wales for regulating and
managing a wide breadth of environmental risks. In some areas of regulation, a structured
and explicit treatment of risk is required; in other areas, the approach is implicit and reliant on
professional judgement. We present a ‘status report’ on the application of risk assessment in
the Agency and some emerging issues with respect to current practice.

Introduction
The emphasis on risk assessment as a management tool for decision-making is reflected in
recent statute but has not been a consistent feature across 30 years of environmental
legislation in the UK. Since its establishment in 1996, the Environment Agency has been
working to structure the treatment of risk within its broad supervisory and regulatory remit.
The Agency’s National Centre for Risk Analysis and Options Appraisal was established in
1997 as a forward thinking centre to progress activities in this field and to lead in the
development of risk-based tools and techniques for application within the Agency. A
synopsis of the present situation is reflected in Table 1, which illustrates a range of tools and
techniques of varying degrees of sophistication in use.

APPLICATION OF RISK ASSESSMENT
Application of environmental risk assessment in the Agency for assisting regulatory decisions
falls into two principal classes: (a) ‘regulatory’ risk assessment, whereby the Agency
undertakes the risk assessment required by statute; for example, in work for the Department of
the Environment, Transport and the Regions, and the European Community, on the
notification of new and existing substances; and (b) ‘applicant’ risk assessment, whereby
operators, dischargers, developers, abstractors, and/or other persons, are required, either by
specific legislation or at the general request of the Agency, to undertake risk assessments in
support of their applications for environmental permits. The majority of the Agency’s activity
in risk assessment is in guiding, reviewing and utilising these assessments, largely as triggers
for regulatory action or for setting conditions on authorisations.

In terms of operational issues and front-line regulation, the Agency is concerned broadly with
three types of situation that cut across its remit:

(i) the risk of an initiating event that may result in a release to the environment, e.g. the
failure of a flood defence structure, a bund, a fuel tank or landfill gas extraction
system, a major chemical accident. Here, analytical tools focus on the failure logic of
‘closed’ systems, through the use of fault- and event-tree models. Procedures focus
typically on the source term;

(ii) the risk of exposure to the wider environment following a release, e.g. the
distribution of particulates from a cement kiln stack, the derogation of a potable water
supply by contamination from a leachate plume. Here the emphasis is on distribution
modelling within an ‘open’ system; the wider environment, and procedures
emphasise the characterisation of environmental pathways;
<table>
<thead>
<tr>
<th>Directorate</th>
<th>Agency Function</th>
<th>Context / Application</th>
<th>Approach / Decision Support Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Protection</strong></td>
<td>Radioactive substances regulation</td>
<td>Safety cases for radioactive waste disposal; radioactively contaminated land (not yet implemented)</td>
<td>Quantitative risk assessment within performance assessment of disposal sites</td>
</tr>
<tr>
<td></td>
<td>Waste management &amp; regulation</td>
<td>Protection of groundwater with reference to EC Groundwater Directive; licensing of installations; inspection frequencies</td>
<td>Qualitative and quantitative risk assessment of waste management installations; quantitative assessment of leachate leakage; risk-ranking schemes for pollution hazard and operator performance</td>
</tr>
<tr>
<td></td>
<td>Land quality (not yet implemented)</td>
<td>Designation of statutory contaminated land</td>
<td>Qualitative risk assessment and quantitative exposure assessment with reference to soil assessment criteria</td>
</tr>
<tr>
<td></td>
<td>Water quality</td>
<td>Groundwater protection with reference to EC Groundwater Directive; discharge consent setting; prioritisation of pollution prevention visits; prioritisation of anti-pollution works</td>
<td>Qualitative and quantitative risk assessment with reference to groundwater protection policy, vulnerability maps and water quality criteria; quantitative distribution modelling of predicted environmental concentrations in surface waters; ranking tools for pollution prevention visits</td>
</tr>
<tr>
<td></td>
<td>Process industry regulation</td>
<td>Authorisation of permits with reference to local and transboundary issues; Safety cases for COMAH sites with reference to EC Seveso II Directive; IPPC; inspection frequencies; notification of new and existing substances</td>
<td>Quantitative distribution modelling of predicted environmental concentrations in air at ground level; fault- and event-trees for safety cases, risk-ranking schemes for pollution hazard and operator performance (OPRA); generic, quantitative exposure assessment models for NONS.</td>
</tr>
<tr>
<td><strong>Water Management</strong></td>
<td>Flood defence</td>
<td>Project risk appraisal for strategic plans and individual flood defence schemes; inspection of flood defence assets</td>
<td>Hazard identification brainstorm techniques for project life cycle risks; probabilistic modelling; fault- and event-trees for engineering risk; ranking schemes for asset management</td>
</tr>
<tr>
<td></td>
<td>Water resources</td>
<td>Assessments of critical flow levels for the granting of water abstraction licences; licence conditions may provide for river support to be provided by abstracter</td>
<td>Low flow hydroecological modelling, objective setting; tiered approach varying from look-up tables to detailed biological response modelling for river assessment</td>
</tr>
<tr>
<td></td>
<td>Fisheries Recreation &amp; navigation</td>
<td>Pilotage of craft within ports and harbour areas operated by Agency</td>
<td>Comprehensive hazard identification and semi-quantitative risk ranking on basis of expert knowledge</td>
</tr>
<tr>
<td></td>
<td>Conservation</td>
<td>Impact of regulated activities on designated habitats with reference to EC Habitats Directive</td>
<td>Sensitivity mapping and ‘environmental footprints’ of regulated sites;</td>
</tr>
<tr>
<td><strong>Environmental Strategy</strong></td>
<td>Sustainable development</td>
<td>Strategic appraisal of environmental pressures on</td>
<td>Environmental impact assessment according to harm attributes; semi-</td>
</tr>
</tbody>
</table>
Table 1: Principal Applications of Risk Assessment (continued)

<table>
<thead>
<tr>
<th>Environmental monitoring and assessment Research and Development</th>
<th>Risk-based compliance and surveillance monitoring (ongoing) Prioritisation of R&amp;D implementation</th>
<th>(under development) Qualitative / Semi-quantitative risk ranking based on delivery and business need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations Areas and Regions</td>
<td>Prioritisation of regional and local Agency plans; Y2K risks to Agency and externally; as support to environmental impact assessments for which the Agency is a statutory consultee; flood risk mapping and development control</td>
<td>Range of tools: most risk ranking approaches</td>
</tr>
<tr>
<td>Finance Corporate Planning / Internal Audit</td>
<td>Identification of business risks over 3 year horizon</td>
<td>Qualitative ‘boston box’ approach of importance and ability to influence</td>
</tr>
<tr>
<td>Personnel Health &amp; Safety</td>
<td>Health and safety risk assessments at work.</td>
<td>Qualitative assessments and checklists</td>
</tr>
</tbody>
</table>

(iii) the risk of harm resulting from exposure, e.g. risks to individuals and properties from the surging flow of flood waters, risks to human or ecological health as a result of exposure to asphyxiant gases, chemical risks from historically contaminated land. Here, emphasis in terms of tools is placed on exposure, dose-response assessments and the varying sensitivities of different receptors.

Some assessments require a full analysis from initiating event to subsequent environmental harm over a range of spatial and temporal scales. Proportionality is an important principle, therefore, in the application of risk assessment and the Agency has placed a strong emphasis on application of a tiered approach. Beyond the project and site-specific level, the Agency is developing procedures and tools for strategic risk assessment that have application for prioritising area and national environmental strategies. The Agency has also developed risk assessment procedures, in consultation with others, for prioritising and resourcing its own regulatory and supervisory work. The development of ‘operator and pollution risk appraisal’ (OPRA) for determining the inspection frequencies of major process plant and waste management installations is an example. Other examples come from areas of corporate planning, construction project management, flood defence asset management and delivery of the Agency’s R&D programme. Good practice guidance is being developed in each of these areas.

**Key Issues**

A set of themes is emerging out of this activity that reflects the status of environmental risk assessment practice currently in the UK. The issue of harmonisation and convergence among approaches and their integration with other decision-making tools is given separate treatment in this volume on account of its importance.
Problem definition. The interests of different stakeholders in the scope, output and use of risk assessments often clouds the study boundaries. Achieving consensus on the conceptual model and study scope has emerged as a critical issue. Assessments conducted for other audiences, such as investors and insurers, for example, will rarely be appropriate for the regulator in support of setting environmental permits, usually because they attend to different aspects of the hazard. Early agreement on the study scope between parties provides a clear steer for the study, can assist in responding to ‘sideswipes’ during the assessment and in communicating output.

Which tools to use – qualitative logic and quantification. A tiered approach\(^1\) allows for risk screening, prioritisation and, in general, a qualitative treatment in advance of quantitation. In practice, many risk problems will be addressed using a qualitative analysis, providing the logic is sound and transparent. Complex environmental issues with significant consequences will invariably require a combination of qualitative and quantitative analysis, usually because certain aspects of the system are better described than others. For example, in radioactive waste disposal, whilst the engineering features of a disposal facility can be described in detail, future exposure scenarios in thousands of years time can only ever be represented by illustrative ‘futures’. These types of assessment require formalised procedures for combining: (i) experimental data with elicited expert judgement; (ii) predictive with illustrative exposure scenarios; and (iii) qualitative with quantitative expressions of risk with their associated uncertainties.

Environmental harm\(^3\) – ‘risks’ and ‘values’. Environmental regulations are increasingly concerned with assessing the risk of adverse effects at the receptor level; that is, in going beyond an expression of harm in terms of a surrogate quality standard. The EC Habitats Directive, the Seveso II (COMAH) Directive and proposed regulations in the UK on historically contaminated land under Part IIA of the Environmental Protection Act, 1990 require assessments of harm; either to designated sites, the wider environment in general, to human health, ecological receptors, or to buildings and property. The need for a more informed interpretation of the characteristics of environmental impact (magnitude, reversibility, latency, spatial and temporal extent etc.), including socioeconomic aspects, is recognised, particularly for comparing consequences from a range of hazards in the context of sustainable development\(^4\).

Skills and competencies. Though seemingly all pervasive, risk assessment remains a discipline in which training is required. Its recent application within areas where judgements have historically been made implicitly, and the involvement of lay audiences in risk assessment design is placing demands on practitioners in terms of transparency of approach, but also highlighting a substantial training need. Calls to simplify assessments for non-experts audiences need to balanced with retaining the analytical power of risk analysis as a management tool, maintaining the underlying logic of approach and utilising the best science available in the analysis.

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ABSTRACT
As the result of past industrial practices, many regions of the world are faced with addressing a heavy environmental burden of hazardous materials with only meager financial resources. In such situations, "risk assessment" is often touted as a means of prioritizing limited resources. However the term risk assessment refers to a number of quite different analysis approaches. Also these risk assessment approaches can often be quite costly to apply. As a result, decision makers have a confusing variety of potentially expensive risk assessment approaches biding for their limited resources. This paper considers and compares the elements of major risk assessment approaches. The use of special approach is recommended using the integrated Human-Centered Risk Assessment (HCRA) concept.

INTRODUCTION
The 1992 Rio Conference introduced the concept of "sustainable development." The realization of sustainable development has proven to be an expensive undertaking that can be afforded only by a few countries in the world community. Legacy issues alone related to decontamination of the environment and neutralization of accumulated waste have proven to be costly undertakings.

In many countries of the world, insufficient national resources limit the ability of the responsible institutions to protect populations from industrial operations and environmental risks as called for in the Rio Conference. Today in many of the same regions of the world, there are clearly increasing trends in illness and anticipated deaths correlated with the quantity and structure of hazardous releases. Immediate protection for these people is needed.

In the past decade the US has started the effort of addressing the legacy of Cold War 1946-1989. Costs have been very high and the projected cost estimates for total cleanup are still increasing. The initial high costs in the US have resulted in a movement towards risk-based decision making for prioritizing these activities. In modern Russia, in other FSU and East-European countries, the resources for starting of similar activities have not been available. The knowledge and experiences of the US in these initial remedial efforts are seen as
important information for FSU and East-European countries, where the environmental problems are more severe and budgets much more limited. This situation led to the identification of the need for focus on local protection of humans subjected to contaminants from a variety of sources, rather than on improvements at the polluted facility. Integrated decision tools are needed to effectively evaluate the risk and the alternatives for its control. An analysis approach is addressed for obtaining optimal protection of the human population and environment even in situations with limited resources [1-5].

**TYPES OF RISK ASSESSMENT ANALYSES**

Two main technical approaches of risk assessment are "facility-centered" and "human-centered." These two approaches are often (incorrectly) seen as competing risk methodologies, when in fact they are quite complementary in nature.

The Facility-Centered Risk Assessment (FCRA) includes the well-known PRA and PSA techniques which are widely used for assessment of risks from potential accidents at a facility. The outcomes of such assessments are used for planning of measures to reduce potential risks by means of increased reliability and safety of facilities. Also included in the FCRA are the Facility-Centered Health Risk Assessment (HRA), that is an examination of the risks from routine operations and minor accidents related too for a single facility. The outcomes of assessments such analysis are used at established of norms and standards for max permissible releases / discharges and concentrations for hazardous facilities and pollutants. Although developed for nuclear facilities, this approach is also being used for chemical facilities [6].

The integrated Human-Centered Risk Assessment (HCRA) considers the impact on individuals of existing contamination and continuing releases from facilities and environmental contamination. HCRA consider the potential local to regional impacts of operations for complex single or multiple facilities. The HCRA methods provide information on potential risks that are not provided by FCRA methods. The HCRA address issues that relate directly to comprehensive and costly administrative decisions which oversight managers are obliged to make.

Early HCRA applications have proven useful. In the United States, the State of Washington used MEPAS to assess the human-centered risks for the multiple possible exposure pathways from a contaminated site [7]. In the U.S. Department of Energy's recent risk various evaluations [8], a modular-risk assessment approach was developed that greatly reduces the time and cost of conducting site-wide studies [9]. This modular-risk assessment approach is an important tool that greatly increases the feasibility of conducting HCRA. In addition, integrated health-based risk evaluations have been conducted by the DOE on (underground storage tanks, water basin storage ponds, etc.) [10], Programmatic Environmental Impact Statement (PEIS) [11], Baseline Environmental Management Report (BEMR), and Waste Isolation Pilot Plant (WIPP) Disposal Phase Final Supplemental Environmental Impact Statement: [12,13]. The DOE's Hanford Remedial Action Environmental Impact Statement (HRA-EIS), evaluated and integrated the impacts associated with 1200 DOE past-practice waste sites at Hanford for 150 constituents, for four land-use options, to an 80-km radius [14]. These evaluations have helped focus the efforts at these sites by providing information on the human health implications for a large number of potential impacts from ionizing radiation and chemical exposures.
In terms of making decisions based on the best available information, both HCRA and HCRA approaches can be implemented as complementary information sources into the procedures of administrative decisions.

When resources are limited, special assessment approaches are needed to conduct less-detailed analyses with lower application costs. Over the past 5 years, the authors have selected special risk technologies for countries with transient and/or unstable economy, namely for FSU and East Europe [1-5]. In addition, the authors are developing a special set of computer systems to allow efficient evaluation of population and environment protection. The objective is to stimulate such activity even in countries with limited risk assessment resources.

CONCLUSION
An integrated human-health risk assessment approach provides a real opportunity to take the first steps in addressing the state of environment and health of people in Russia, countries of the former Soviet Union, Eastern Europe, and middle Asian countries. Existing models will allow the characterization of environmental problems with a reasonable expenditure of resources. This characterization will provide information that people can use to reduce their risks and decision-makers to prioritize any risk-reduction activities.

To be successful with limited resources in protecting people and the environment, regional systems need to be developed for control, assessment, and interpretation of data on dangerous industries, transportation, and environmental conditions. A base of trained managers and advisers in each region will be needed to apply the new methods. It is also anticipated that no one program will meet all needs because each major application will need to reflect special processes, conditions, and concerns. This risk methodology approach allows countries to use their own resources to start the process of meeting the recommendations of the Rio conferences.

BIBLIOGRAPHY


COMPARATIVE RISK ANALYSIS OF HEALTH CONSEQUENCES CAUSED BY CONTAMINATED ENVIRONMENT.

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ABSTRACT
The paper deals with the generalized probabilistic approach for analyzing health consequences caused by various exposure factors. Formally basing on the competitive risk theory, it is introduced a general risk model for analysis the influence of environmental risk factors to human health. The usefulness of the model approach is in the opportunity of taking into account: time delay of impact and consequence manifestation; easy comparisons of exposure factors with different nature and various consequences (morbidity and mortality, carcinogenic and genetic); social and environmental components in overall mortality. Preliminary examples of comparative risk analysis are demonstrated on the Russian demography and environmental data with the attempt of characterizing the dynamical tendencies and evolution of introduced risk index. The prospects of the probabilistic approach and the results obtaining on this basis are discussed.

INTRODUCTION
In [Bykov, Pronina 1999] general probabilistic model describing the age dependent mortality data introduced. Three component model is based on the general probabilistic approaches and following proposals: 1) the general population is heterogeneous and could be divided into at least two sub-populations: small alpha moiety – weak and sensitive, containing genetic harm, and the best part – normal population; 2) for heterogeneous population hypothesis of independence of risk factor influencing was introduced; 3) the distribution laws are chosen basing upon the general probabilistic theorems and probabilistic formalism suggested in in [Bykov, Demin 1991; Bykov, Murzin 1997]. The age-dependent mortality rates are represented by three components:

\[
\text{Mortality rate (Heterogeneous population)} = \frac{\text{Alpha} \times \text{Weibull type d.d.f.}}{1.0 - \text{Alpha} \times \text{Weibull type s.f.}} + \frac{\text{Normal d.d.f.}}{\text{Normal s.f.}} + \text{Environmental component of mortality rate}
\]

Arguments for choosing this type of model functions and the form of environmental component for chronic exposure can find in [Bykov, Pronina 1999]. Fitness of this model to statistical data is good (see Fig.1., the same kind of curve on logarithmic scale is presented in [Bykov, Pronina 1999]). In this paper we demonstrate some examples of dynamical tendencies of model parameters.

1. DYNAMICS OF ALPHA VALUE
This parameter determines the contribution of weak sub-population into general heterogeneous population. According to our proposals this value is strictly correlating with genetic detriment of general population. The results for this value obtained on the statistical data of mortality rates in Russia [Mille, Shkolnikov, et al, 1996] from 1965 to 1994 show, that
Alpha value varies in the range from 0.02 to 0.04 and has a slight tendency of decreasing. This can be explained by the decreasing weight of genetic harm, and this tendency is corresponding to the tendency of environmental component decreasing. Another feature: Alpha value for men is greater than for women, that is in well agreement with the higher male sensitivity to the influence of environmental exposure factors.

2. DYNAMICS OF GAMMA VALUE
We used the simplest Weibull type distribution – exponential with parameter gamma. Revised gamma value determines the mean time for manifestation of genetic harm in weak sub-population. This parameter is approximately the same for males and females, slightly varying and close to the 0.55 (1/year).

3. DYNAMICS OF T0 AND SIGMA VALUES
The second component of the model is described with the help of normal distribution low with parameters T0 and SIGMA. T0 value characterizes the mean age of death with deviation proportional to SIGMA. The results of model fitness for the T0 values are rather unusual. For normal part of the population, if excluding the violent causes of death and the influence of environmental risk factors, the mean life time should be close to 93 years for males and 103 years for females (see Fig.4). This value is slightly high at the end of 60s and decreasing from the end of 80s, especially sharp for males. This is the influence of the decreasing level of life connected with the economical reforms in Russia.

SIGMA values are quite close for males and females and varies around 20-21 years. And it could be seen (Fig.5), that for the decreasing period of T0 (from the end of 80s) SIGMA value is increasing, that again can be easy explained by the population reaction on increased stress factor.

4. DYNAMICS OF ENVIRONMENTAL RISK INTENSITIES
Environmental component of age dependent mortality rates increasing in the beginning of age interval rapidly tends to value, which is practically constant over all age range. The dynamics of this value – environmental risk intensity is demonstrated on the Fig.6.
It is seen, that this value varies in the range $(2-6) \times 10^{-4}$, with the tendency of decreasing, especially it is character for males since the middle of the 80s. It could be explained by the decreasing industrial activity in Russia and the corresponding decreasing of environmental contamination.

Estimated by general model fitting environmental risk intensities values $(2-6) \times 10^{-4}$ are in a good agreement with the estimation of total risk to human health caused by contaminated environment [Revich and Bykov 1997]. Using levels of suspended particles in the polluted ambient air assesses this contribution. As it is seen from the Table 1, the average individual risk of death from environmental contamination is close to $(4-5) \times 10^{-4}$ and falls to the range of environmental risk intensities. It confirms the validity of the results of comparative analysis represented in the Table 1, and at the same time confirms the correctness of the introduced general probabilistic model.
CONCLUSIONS
Results of comparative analysis lead us to the following:
1) Environmental pollutions do not produce the death risks in the HIGH hazard range.
2) The most hazardous air and drinking water pollutants produce death risks in the MIDDLE hazard range. The death risks of:
   - air pollution (defined through suspended particles) equivalent to the death risks from such diseases as chronic bronchities, suicides, murders, all accidents or transport accidents; diabetes, chronic alcoholism and alcoholic psychosis, all accidents except transport, falls, drownings;
   - arsenic is compared with death risk of Fires;
   - vinyl chloride and cadmium can be compared with nature disaster risks;
   - air pollutions of benzene, nickel, benzo(a)pyrene, dioxins are equivalent to drinking water pollutions of arsenic, chloroform and trichlorethylene, and all they comparable with such natural risks as flood, tsunami, earthquakes, typhoons, cyclones or storms.
3) The less hazardous air and drinking water pollutants produce death risks in the LOW hazard range. The death risks of:
   - air pollutions of formaldehyde and cadmium (Moscow) are equivalent to drinking water pollution of carbon tetrachloride, and they comparable with thunder storm natural risk;
   - air pollution of nickel (Moscow) is equivalent to drinking water pollution of beryllium and benzo(a)pyrene, and to hurricane and tornado natural risks.

GENERAL CONCLUSIONS
Preliminary analysis of dynamical tendencies shows a slight decrease of alpha value, reflecting genetic harm of population decrease. Stability of net-life-time (dispersion) till the end of 80th and tendency to decrease (increase) since the beginning of 90th is observed. It lead us to the conclusion that developed general probabilistic model could be a good basis for planning future studies, connected with thorough investigation of environmental risk model component for acute and chronic exposure; dynamical analysis of different types of environmental exposures influences; introduction of environmental risk equivalent factors; estimation of complex environmental influence on human health.

Table 1. Comparative analysis of population death risk orders for Russia [Revich and Bykov, 1997]

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<tr>
<th>Health hazards</th>
<th>Range of annual death risk</th>
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<td>Ambient air pollutions:</td>
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<td>Suspended particles</td>
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<td>Dioxin (Moscow)</td>
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<td>Formaldehyde</td>
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<td>Cadmium (Moscow)</td>
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<td>Beryllium</td>
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| Suicides                  | x      |
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<td>Hurricane, tornado</td>
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Preliminary analysis of systematic data shows a clear correlation between differing social groups and health outcomes. Further analysis is needed to confirm these findings.
ABSTRACT
In 1999, the UK government launched the Scientific Basis of Risk project to enhance health and environmental risk assessments for chemicals. The project was intended to produce methods for calculating risks from chemicals that are consistent with the latest science and understanding of human exposure. The project has recently been updated to include a focus on food-related risks.

METHODS FOR FOOD/HEALTH RISKS

BACKGROUND
The current methods for assessing risks to human and environmental health rely on the use of a tiered approach that involves the use of different models and methods depending on the level of risk. This approach is based on a probabilistic risk assessment framework that takes into account the uncertainty and variability in exposure and response. However, this approach has limitations, and there is a need to develop more robust methods for assessing risks to human and environmental health.
TRACK 2

Session 1

METHODS FOR FOOD/HEALTH RISKS
DEVELOPING NEW APPROACHES TO ASSESSING RISKS TO HUMAN HEALTH FROM CHEMICALS

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ABSTRACT
In 1996 the UK government departments involved in the assessment of risks to human health from chemicals started a new initiative. The aim was to review current practice for managing risks to health from chemicals and in the longer term to promote the development and validation of innovative approaches to generate better estimates of risk and improved risk assessment procedures.

The presentation will summarise the progress that has been made. At the outset it was realised that there are important, though justifiable, differences between the risk assessment schemes used by departments, often reflecting requirements of EU Directives or other international agreements. To articulate the approaches used across Government a review, Risk assessment approaches used by UK Government for evaluation human health effects of chemicals has been published.

Three workshops have been held to address key issues. These brought together regulatory toxicologists and policy makers from government and experts from academia and industry and resulted in a series of recommendations aimed at improving risk assessment procedures. The topics covered were; how population subgroups were accounted for in chemical risk assessment; the use of physiologically based pharmacokinetic modelling as a risk assessment tool and exposure assessment. A final workshop on dealing with uncertainty involved risk assessors from government departments considering a number of case studies. A report from each workshop is published.

Recommendations from the workshops and the review of approaches will used to draw up an action plan for future work and identify research priorities. The aim is for international consortia to be brought together to fund research. In the longer term the outcomes of the research will be used to promote agreement on improved risk assessment procedures for incorporation into international regulations.

BACKGROUND
The current methods for assessing risks to humans from chemicals rely heavily on data from tests carried out on animals. There are inherent limitations in these methods arising from the need to extrapolate results obtained from exposing experimental animals to the chemical, often in large amounts, to the human population, normally exposed to much lower amounts. Government departments, recognising these limitations articulated the need to develop improved methods in a statement in the 1995 UK Government “Forward Look of Government Funded Science, Engineering and Technology.” The Forward Look committed Government departments, together with the relevant Research Councils, to making a co-ordinated drive to pursue the important opportunities presented by recent scientific advances.
This led to the establishment in 1996 of the Government/Research Councils Initiative on Risk Assessment and Toxicology. The work of the Initiative has been taken forward by Risk Assessment and Toxicology Steering Committee, an informal committee of officials from government and the Research Councils. The Steering Committee has developed a programme of work for the Initiative, planned a series of workshops and managed the production of reports. Funding for the provision of secretariat services has been made available to the Medical Research Council's Institute for Environment and Health (IEH) by participating departments and Research Councils.

Workshops were held on different aspects of risk assessment to help identify research needs. These brought together regulatory toxicologists, policy advisers from Government and experts from academic institutions and industry to consider in depth a specific area of the risk assessment process and to make recommendations.

The original remit of the Initiative as set out in the Forward Look statement focused on the scientific methods used in risk assessment, particularly the toxicological evaluation of chemicals. Recent developments connected with the public appreciation of risks have raised the profile of, and had enormous implications for, the way the UK Government and its agencies approach risk. The Steering Committee has reacted to these influences by broadening its work to include policy issues relating to chemical risk assessment. Of particular interest to the Initiative are issues relating to consistency and transparency of approach.

OUTPUTS
At the outset, the Steering Committee realised that there are some variations between the risk assessment schemes used by UK Government departments and agencies. Risk assessments are carried out and used in different ways to inform specific risk management decisions (for example, granting permission to market a pesticide for a specific use, setting an air quality standard). The procedures often reflect requirements of EU directives or other international agreements and each scheme has been developed independently, although on the basis of the same underlying fundamental principles. The Steering Committee has provided, for the first time, a forum for an interchange of views between departmental representatives involved in the operation of the different schemes.

In order to articulate the approaches used across Government the Steering Committee commissioned a review "Risk assessment approaches used by UK Government for evaluation human health effects of chemicals". The review looked at the risk assessment process, the type of information required and how it is collected, who evaluates the data and the framework for data evaluation. It was concluded that there is wide agreement across Government departments and agencies on the philosophies and methodologies used in chemical risk assessment. Nevertheless, there are diversities of approach in dealing with the difficult areas of:

- uncertainties – in extrapolating data from animal tests to humans in respect of health effects and in the estimation of exposure;
- variability – within the human population and in estimates of exposure;
- gaps in the data on hazard identification – eg. many chemicals have not been tested for effects on reproduction.
On the basis of emerging priorities identified during the preparation of the review, the Steering Committee sponsored workshops on four important aspects of risk assessment. The first three workshops followed a common format of presentations from policy-advisers and experts from academic institutions and industry followed by discussions of key issues leading to a series of recommendations. The fourth comprised a discussion by Government risk assessors discussing of how uncertainty is handled in four specific risk assessment schemes, using a series of case studies. A report of each workshop has been published. The topics covered by the workshops were:

- Risk assessment strategies in relation to population subgroups;
- Physiologically-based pharmacokinetic modelling: A potential tool for use in risk assessment;
- Exposure assessment in the evaluation of risk to human health; and
- From risk assessment to risk management: dealing with uncertainty

Finally the committee published an overview report setting out the work of the initiative and future plans.

The review and the workshops contain a series of recommendations aimed at addressing the diversities of approach and improving the risk assessment process. These were divided into three groups:

- harmonisation
  - of data requirements
  - practice in toxicological assessments
  - practice in intake and exposure assessments
- development of improved methods and new approaches to risk assessment;
  - improvement of existing methods
  - developing and validating new in vitro or computer based methods
  - accounting for multiple exposures
  - rationale for worst case exposure estimates
- improved transparency
  - articulating the influence that risk management has on the way risk assessments are used
  - publication of risk assessments
FUTURE DIRECTIONS
The work of the Initiative has laid a firm foundation from which further progress can be made in the three key areas identified: harmonisation; development of improved methods and new approaches for risk assessments; and improved transparency.

The Steering Committee will continue to take forward the work of the Government/Research Councils Initiative on Risk Assessment and Toxicology, but, to reflect the broader remit, will be known as the Interdepartmental Group on Health Risks from Chemicals. The remit of the group is:
To secure improvements in chemical risk assessment in relation to human health by:
- promoting the development of improved methodologies;
- promoting improved approaches to risk assessment;
- promoting coherence and consistency in the practice of risk assessment;
- disseminating and advancing best practice.

The IGHRC will continue to provide a forum for an interchange of views between departmental representatives involved in the management of health risks from chemicals. One of the IGHRC’s first tasks will be to examine the recommendations in the reports and develop a research strategy. This will be discussed with the research community, Research Councils and other stakeholders with a view to engaging them in the implementation of the strategy. In addition, departments propose to collaborate in funding a number of “pump priming” projects to stimulate the development of new techniques. A number of the recommendations relate to risk assessment policy. To promote progress in these areas, activities will be developed which will reflect the international nature of chemical risk assessment work and determine where attempts should be made to influence UK and EU policy or OECD work.

CONCLUSION
The IGHRC provides a unique forum for departmental representatives with an interest in chemical risk assessment to discuss common issues and develop solutions. During the first phase considerable time was spent analysing the issues and developing a series of recommendations. The arrangements made for the second phase should allow rapid progress to be made on policy issues and in the drawing up and implementation of a research strategy.

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4. Exposure assessment in the evaluation of risk to human health (cr5)
5. From risk assessment to risk management: dealing with uncertainty (cr6)
6. Developing new approaches to assessing risk to human health from chemicals (cr1)

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Executive summaries of these reports are available on the ILGRA website:
http://www.open.gov.uk/hse/dst/ilgra.htm
USE OF ANALYTICAL TECHNIQUES IN RECONSTRUCTION OF DIETARY INTAKES: APPLICATION TO TECHA RIVER POPULATION

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INTRODUCTION

Internal dose in general and specifically internal radiation dose can be calculated as:

\[ \text{Internal Dose} = \text{Intake} \times \text{Dose Conversion Factors} \]  

Dose conversion factors are contaminant-specific and often determined by physiologically-based pharmacokinetic models, calculation methodology and associated uncertainties have been well documented for radionuclides (NCRP, 1998) [1]. Intake calculations are case- and site-specific. In many dose reconstruction projects, multimedia modeling is used to establish contamination levels for food and water and then intake is reconstructed based on exposure scenarios for different population groups. The uncertainty in intake reconstructed using such modeling is usually very large because of model and parameter uncertainties. Less uncertain intake estimates can be achieved utilizing measurements of contaminating agents in the body (whole-body counting in case of radionuclides) or excreted from the body (urinalysis). Nevertheless, when intake occurs over protracted time period and bioassays are taken long after exposure, the intake reconstruction is a challenging task.

This paper presents a radionuclide intake reconstruction methodology for populations living along the contaminated Techa River in Russia. Currently, there are significant international efforts under way to use this population to evaluate health consequences of protracted exposure to low-doses of radiation. Since direct dose measurements are fragmented and uncertain, dose reconstruction is of crucial importance. Even though the presented methodology was developed specifically for radionuclide intake reconstruction, it can be generally applied for other contaminants and other contamination scenarios.

TECHA RIVER CONTAMINATION

Techa River is a small river in Russia that is highly contaminated by radionuclides as the result of nuclear operations in the early 1950s. The populations living along the Techa River (Techa River Cohort, TRC) was significantly irradiated. The main pathway of dose accumulation for riverside individuals was internal irradiation by beta-particles of ingested Sr-90, which is a "bone-seeking" radionuclide that efficiently concentrates in human bones close to the most radiosensitive biological tissues: the red bone marrow and osteogenic cells of bone surfaces. The largest doses of internal irradiation were accumulated by teen-agers in the 1950's whose skeletons were growing rapidly in the period of maximal contamination. The main source of ingested strontium in 1950-1951 was drinking water from the river. Later, after usage of the river water was prohibited, the main source of radionuclides intake was milk from cows pastured in the contaminated territories. Radiation exposure for the TRC cohort occurred mainly in 1950-1955 because of implementation of tighter environmental regulations and evacuation of many residents and therefore the radionuclide intakes at later time periods can be neglected.
INTAKE RECONSTRUCTION METHODOLOGY FOR TECHA RIVER COHORT

The dietary intake of a contaminant, required for dose reconstruction in Eq. (1), is often unknown. Radionuclide content in the body can be estimated through indirect measurements, such as whole-body counting, concentration measurements in urine, etc. In this paper we report reconstruction of Sr-90 intake using Teeth Beta Counting (TBC) measurements in tooth enamel [2]. The tooth enamel is formed only in the first years of life. After that almost all mineral exchange processes stop. The measured radioactive decay is only from the strontium-90 that entered the enamel in childhood. It could be said, that the enamel of those who were children in the 1950's, stores a "snapshot" of the strontium intake for this person mainly for these particular years.

Radionuclide intake can be back-calculated using measured TBC, \( C \), for different age-cohorts:

\[
1955 \quad C(birth \ year) = k \sum_{year=1950} I(year) \cdot f(age(year)) \cdot a(age(year)) \cdot r(year, age(year))
\]  

(2)

where \( k \) is the measurement calibration constant (counts per Bq), \( I(year) \) is reference Sr-90 intake for an adult person, \( a(age(year)) \) is the age of the person, \( f(age) \) is the transfer factor of Sr-90 from person's diet to the person's teeth enamel, and retention factors \( r(year, age) \) are required to correct radionuclide content to the excretion from the body by the time of measurements (only radionuclide decay can be taken into account in the retention factor for teeth enamel).

If all other parameters in the Eq.(2) are known, intakes for 1950-1951 can be calculated using TBC measurement in at least 6 age-cohorts. Unfortunately, transfer factors from diet to teeth are highly uncertain, and should be considered as unknown parameters in Eq (2) [2]. Thus equation (2) sums products of multiple uncertain factors, and the problem of intake reconstruction is therefore nonlinear and can have many solutions.

Kozheurov and Degteva (1994) solved system of Eq. (2) for 10 unknown intakes and 10 unknown transfer factors numerically [2]. They vary intakes and transfer factors to obtain TBC values, predicted by formula (2), and then used the least-square fitting of these predicted values to actual measurements. The danger of implementing of such numerical methodology is in possible multiple solutions of the system of Eq. (2), and, as a result, high sensitivity of the numerical solution to its initial approximation. Therefore, solution obtained in [2] may be just one of many possible solutions, not necessarily the optimal one.

In this paper we propose a new approach to intake reconstruction that uses analytical solution of the system of Eq (2). The main idea of this approach is in sequential finding of all analytical solutions of these equations starting with the most simplified situation with three equations and three unknown variables (taking account of only one unknown intake, and two unknown transfers factors), and then increasing the number of equations and variables stepwise. At each step, all solutions are analyzed against a set of physical constraints developed \textit{apriori} based on the expected properties of the optimal solution. The following constraints were used:

1. solutions must be real and positive;
2. Sr intake must decrease with time after 1950, consistently with the decrease in concentration of Sr-90 in river water;
3. Transfer factors must decrease with age at intake, consistently with teeth formation physiology.
Solutions for each degree of the system complexity that met all three constraints were then selected as optimal ones. For consistent datasets, the optimal solutions reconstructed from the systems (2) with different degrees of complexity should not vary much. The best solution can then be obtained by any numerical method for the solution of the system of nonlinear equations (2), or using least square methodology, similar to that implemented in [2], utilizing information on the optimal analytical solutions to build initial approximation.

**RESULTS**

To solve Eq. (2), we expressed unknown intakes in the units of intake in 1950, \( I(1950) \), and transfer factors in units of \( k/I(1950) \).

We started with the system of three equations (2) and three unknown parameters: \( I(1951) \), \( f(0) \), \( f(1) \), neglecting data for intakes after 1951, and transfer factors for children older than 1 year. No real solutions were found.

Then we increased the number of unknown intakes and transfer factors to 4. It is possible to add the next: 1) intake, or 2) transfer factor. In each case, one real solution was found, but only the one with added intakes satisfies the constraints (3) (see Table I).

All solutions were rejected for the case of 5 unknown parameters (added one more transfer factor or intake) because the best possible solution satisfies constraints 1 and 2, but not the constraint 3 (it provides higher transfer factor for older children).

For the system with 6 unknown variables (intakes in 1951 and 1952 and transfer factors for the ages 0-1, 1-2, 2-3 and 3-4 years) optimal solutions were found (Table I).

The complexity of the solutions is rapidly growing with increase of the number of unknown variables. We were able to obtain optimal solutions analytically only for up to 7 unknown parameters in the systems of equations (2). The solutions are presented in Table I. They are close to each other (and close to rejected best solution for the case of 5 unknown parameters).

The ranges of variation of intakes for 1951-1952 and transfer factors for children 0-3 years old were used as inputs for a numerical solution with 18 unknown parameters (this is the maximal complexity, determined by the number of age-cohorts with available TBC measurements). The obtained numerical solution is close to analytical solutions with 6 and 7 unknown parameters (Table I).

Figure 1 plots reconstructed Sr-90 intakes and transfer factors. The required value of Sr-90 intake in 1950, \( I(1950) \), was reconstructed from whole-body counting data, similarly to [2], but using our new values for the relative contributions of each year of the intake to the total intake. The mean value of \( I(1950) \) is 43493 nCi/year. Absolute values of the transfer factors can not be obtained, because the calibration constant \( k \) for TBC is unknown. Our solution differs significantly from the intake data reported in [2], but its consistency with Sr-90 concentration in water [3,4] is better. This difference will result in changes in dose estimates for TRC. Our analysis shows that the maximal corrections for dose estimates should be done for the persons born after 1949 (data not shown).
Table I Intakes of Sr-90 and Transfer Factors for residents of Muslimovo Village. Intakes are given in units of intake in 1950; transfers factors are in units of $k/I_{1950}$ (see Eq.2).

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<th>Variables</th>
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<tr>
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<td>Numerical Solution</td>
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Figure 1. Reconstructed Average Intakes of Sr-90 at the Muslimovo Village for an adult man and transfer factors from diet to teeth enamel.

CONCLUSION
Intake reconstruction is an important part of dose reconstruction projects. We have developed new intake reconstruction methodology that is based on sequential analytical solutions of the system of non-linear equations, using portions of available measurement data, with subsequent numerical solutions using the whole available measurement database. The major advantage of our approach is in using analytical solutions for initial conditions. Implementation of the proposed approach guarantee finding unknown radionuclide intakes and transfer factors that are consistent with actual data on radionuclide concentrations in teeth and bones, and moreover, within the set of constraints based on our knowledge about the specific of the contamination and mechanisms of intake.

Currently we are developing a probabilistic approach to intake reconstruction. We will use reconstructed average values of the intakes and transfer factors to develop probability distributions for these uncertain parameters and Bayesian updating methodology to reduce associated uncertainties.
ACKNOWLEDGEMENTS

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REFERENCES


PROBABILISTIC MODEL OF THE AGE-DEPENDENT POPULATIONS’ MORTALITY AS THE BASIS FOR THE ANALYSIS OF ENVIRONMENTAL POLLUTION INFLUENCE ON HUMAN HEALTH

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ABSTRACT

Probabilistic model of age-dependent population’s mortality with the decomposition to causal competitive risk factors is presented. This approach includes three competitive risk elements: genetic, environmental and others (connected with ageing). Population represents as heterogeneous aggregate with substantially different abilities to overcome the influence of external risk factors. From positions of the probabilistic approach the typical curve of age-dependent death rate is well described by a specially selected net-probability distribution functions, the laws of which were guided by general theorems of probabilistic theory and common reasons. Analysing the qualitative picture of death distribution density function it was made the assumption, that the given density function forms by at least three competing death risks. The well agreement of proposed model predictions with the statistical data is demonstrated on the mortality data of Russian population for the time period 1965-1994. Analysing time series of fatigue function parameters it was shown that modification of parameters could judge environmental influence on a death rate picture. This kind of analysis could show dynamic tendencies of genetic weight in the mortality and help to explain the reasons of mortality tendencies and make prognoses for the future.

Introduction

The influence of contaminated environment to human health is acting together with different competitive risk factors: transport and other accidental and violent causes, social stress factors, organism internal features, genetic harm luggage and some others. The general probabilistic approach for studying the influence of competitive risk factors to health (including contaminated environment) is described in [Bykov, Demin 1991; Bykov, Murzin 1997], where the strict formalism is proposed for calculating the competitive risks and natural health detriment in terms of weighted life time reduction. According this approach, to study the competitive independent risk factors it is necessary to evaluate the net-probability distribution laws for each independent risk factor is acting in the hypothetical conditions of absence the competition with other risks. Then the competitive risks can be calculated using the net-probability cumulative functions and densities. It is shown also, that the age mortality rates can be represented as the sum of intensities of different independent risk factors, where every intensity component is evaluating by the corresponding to risk factor net-probability density and cumulative (survival) function:

\[ \text{Mortality rate component} = \frac{\text{Density distribution function (d.d.f.)}}{\text{Survival function (s.f.)}} \]

The proposed approach is fruitful allowing comparing the exposures and consequences of different nature, time delay of exposure and consequence manifestation, to take into account the effect of risk competition, and to introduce the generalized index of health detriment. The
applications of the proposed probabilistic approach to the analysis of radiation risk factor are demonstrated in the mentioned work. This study is developing the probabilistic approach. The main idea is to introduce a simple probabilistic model based upon the general theorems and rational proposals for describing the age dependent mortality rates. To validate the model there were used the statistical data of mortality rates in Russia [Mille, Shkolnikov, et al, 1996] from 1965 to 1994. The same data also allow to look through some dynamical tendencies of model parameters.

1. General probabilistic competitive risk model describing the age-dependent mortality rate

The curve of age dependent mortality rates (Fig. 2 (a, b)) have its own typical features as high values of mortality rates in the child age interval; decrease of mortality rate up to the age of approximately 10. Since the age of 40 years the dependence of mortality rate is quite linear, and is often described by the linear well known in demography Hompertz function or some others (Meikham, Weibull).

Hompertz or Meikham functions give a good fitness to the statistical mortality data, but only for 40 - 80 age interval. Very often the data show nonlinear character at the ages higher than 80, and can't be well approximated by mentioned functions. And these functions absolutely unavailable for describing mortality rates in the young age groups.

Age interval, where Hompertz and Meikham functions well fit the data, could have wide beginning from the 20-30 years, if we exclude violent causes of death (as it is seen on Fig.2b). Note, that this nonlinearity sometimes incorrectly explained by the action of all exogenous factors [Blinkin, 1998], wherein violent causes are only the part of them. In [Bykov, Demin 1991; Bykov, Murzin 1997] it is shown, that the following function

\[
\text{Mortality rate} = \frac{\text{Normal d.d.f.}}{\text{Normal s.f.}}
\]

could be effectively used for the purposes of mortality rates approximation in the wide age range and able to give a good fitness to nonlinear part of curve in the old age range. This suggestion will be used below in the general probabilistic model.

To explain the mortality features at the initial part of the curve, we proposed that the population is heterogeneous and could be divided into at least two sub-populations: small alpha moiety – weak and sensitive, containing genetic harm, and the best part – normal population, as it's shown on the following scheme:
1. Normal sub-population. The normal part of population we introduced the following proposals:
1) Death is a result of multifactor multistage process. In other words, we suggested that if we exclude the violent causes of death, the aging process could be proposed as multistage (N-stage) with random times $T_i$ of i-stage:

![Diagram of multistage aging process]

If $N$ is not very small, the distribution of life-time random value $T = T_1 + T_2 + \ldots + T_{N-1} + T_N$ tends to the normal (Gauss), and

Mortality rate (Normal population) = $\text{Normal d.d.f.} / \text{Normal s.f.}$

2) Environmental component of mortality rate could be described as a product of exposure intensity, deviation of dose-response function and cumulative net-probability function divided by one minus product of exposure intensity, deviation of dose-response function and integral from 0 to age $T$ from cumulative net-probability function.

It is shown in [Bykov, Demin 1991; Bykov, Murzin 1997], that this form of equation could be used for the description the effects of chronic exposure. We used this equation for the mortality rate component reflecting the influence of environmental factors. It is important to note that this component is slightly dependent in time over the age of ten years and can be taken a constant.

1.2. Weak sub-population. For the weak minority of population we assumed that
1) Death is quite soon and wait upon genetic harm. On this understanding, the distribution of life-time random value $T$ could be chosen through the character of mortality rate dependence in the young age groups. In our case it was chosen Weibull type of distribution function (exponential distribution).

Mortality rate (Weak population) = $\text{Weibull type d.d.f.} / \text{Weibull type s.f.}$

2) Weak population is also exposed by factors, characteristic to normal population. In this case

Mortality rate (Weak population) = $\frac{\text{Weibull type d.d.f.}}{\text{Weibull type s.f.}} + \frac{\text{Normal d.d.f.}}{\text{Normal s.f.}} + \text{Environmental component of mortality rate}$

1.3. Heterogeneous population. For heterogeneous population we put forward an additional hypothesis - hypothesis of independent influencing factors. This proposal together with the previous ones give the following general probabilistic model

Mortality rate (Heterogeneous population) = $\frac{\text{Alpha \times Weibull type d.d.f.}}{1.0 - \text{Alpha \times Weibull type s.f.}} + \frac{\text{Normal d.d.f.}}{\text{Normal s.f.}} + \text{Environmental component of mortality rate}$

2. PARAMETER ESTIMATION.
We used two-step procedure for estimating the parameters of the introduced model.
Fig. 1a. Q-Q plot for Weibull distribution

Fig. 1b. Q-Q plot for Gauss distribution

Fig. 2a. Observed total mortality rates (females, 1965) and model curves

Fig. 2b. Observed values (males, 1965) and model predictions (violent causes of death are excluded)
1st step: We divided the age scale into two parts: young age range (less than 15) and older age range (15 and older). For each range, using a technique of quantil-quantil diagrams (see Fig.1a,b) and regression analysis we made a rough estimation of parameters.

2nd step: For better fitness we made parameter variation with minimization of revised relative deviations. Results obtained for different steps can be seen on Fig.2 (a,b).

Conclusions
Results obtained show that proposed general probabilistic model is in the good agreement with observed demographic mortality data; most model parameters have simple sense, interpretation and dynamical stability. It lead us to the conclusions that the developed general probabilistic model can be used as a basis for the future studies, connected with analysis of various causes of mortality rates.

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THE ASSESSMENT OF CARCINOGENICITY AND ITS ROLE IN RISK ASSESSMENT OF CHEMICALS IN THE NETHERLANDS

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ABSTRACT
In the seventies the Health Council of the Netherlands drew up the first of a series of guidelines for risk assessment of chemicals. One of them dealt with evaluation of carcinogenic potential. Its hallmark was the recommendation in 1978 to divide compounds with carcinogenic properties into two categories, later termed genotoxic and non-genotoxic, on the basis of their mechanism of action. Genotoxic carcinogens are assumed to pose a cancer risk at any concentration, in other words: with these carcinogens there is no such thing as a safe level of exposure. Non-genotoxic carcinogens are assumed to have a threshold value, a level beneath which cancer will not be induced. With a genotoxic carcinogen, linear extrapolation is the recommended method for estimating the risks associated with a given level of exposure. The approach is suitable for risk assessment since it is easy to use and requires little data on the substance in question. It recognises the meaning of for instance tumours at high doses. World-wide the Council was among the first to approach risk of carcinogens in this way. Following the Council's recommendation chemicals have been assessed this way since in the Netherlands.

In the past few years the Health Council identified some substances that do not fit into the scheme comprising two categories. We discuss how these insights have modified risk assessment of carcinogenic chemicals and how they are dealt with presently in various policy fields, concentrating on ambient and occupational air quality.

INTRODUCTION
The Health Council of the Netherlands (Gezondheidsraad) is a statutory advisory body to the Dutch government. It informs the government on the level of scientific knowledge in the field of health care, public health and environmental protection. Autonomous multidisciplinary expert committees, most of them of ad hoc nature, make up the reports. In the seventies several guidelines were developed for risk assessment of chemicals and systematic risk assessment of (groups of chemically or toxicologically related) substances was initiated.

One of the guidelines, issued in 1978, dealt with assessment of chemicals as to carcinogenic (cancer-inducing) properties including establishment of toxicology-based recommended exposure limits (TBRELs), levels that under specified circumstances do not pose a health hazard higher than a predetermined one (1). Its hallmark was the recommendation to divide carcinogens into two categories according to their mechanism of action. These categories are compounds posing a risk at any concentration (acting stochastically) and those posing no health risk below a certain concentration, the so-called threshold (acting non-stochastically). The former possess the capacity to irreversibly modify the information stored in DNA, the latter do not. They are referred to as 'genotoxic' and 'non-genotoxic', respectively. For the most recent criteria to distinguish these two categories the reader is referred to one of the Health Council's reports (2). For genotoxic carcinogens linear extrapolation was considered appropriate to establish a concentration associated with a risk not higher than a set level, for non-genotoxic ones a no-observed-adverse-effect level divided by a safety factor was the recommended approach. Various mathematical methods for performing linear extrapolation
exist. The one proposed by the Council is relatively simple to perform and requires little data (cf. ref. 1). This also holds true for the threshold-method. Therefore the Council's approach is suitable for many chemicals. Another important advantage is that TBRELs for genotoxic carcinogens are based on tumour data, whereas those for non-genotoxic ones may be based on any effect considered threatening to health. In animal experiments many non-genotoxic chemicals have been shown to cause tumours at high doses; these are the result of the massive toxicity caused by these doses (1,3). In these cases linear extrapolation based on the tumours would lead to unnecessarily low concentrations. The approach advocated by the Council avoids this conservatism, because the TBRELs for non-genotoxic carcinogens are based on the adverse effect detected at the lowest dose.

The scheme comprising two categories was implemented in the Netherlands. With this approach the Council was among the first to recognise that not all carcinogens require a conservative method for assessing health risk, such as linear extrapolation. Presently mechanism-driven risk assessment of carcinogens is also applied elsewhere.

For many chemicals TBRELs have been established as described. The scheme comprising two categories is applied to chemicals irrespective of the policy field; the TBRELs differ however, because the exposure pattern and the accepted levels of risk are taken into account (4). We will focus on compounds present in ambient and workplace air: chemicals marked as priority ones by the Ministry of Housing, Spatial planning and Environment and those prioritised by the Ministry of Social affairs and Employment.

**EXCEPTIONS TO THE RULE**

A few years ago the Health Council evaluated the guidelines for assessment of carcinogenicity (3). The Council thought it advisable to reserve the option of departing from the 1978 approach in special cases. This notion was based on experience obtained with some chemicals, among them arsenic and cadmium. The genotoxicity of these substances could be explained by inhibition of DNA-repair enzymes (5,6). Thus, it is not the result of direct interaction of the compound with the DNA, the situation that would require linear extrapolation. The solution proposed (and implemented) was a threshold, the method previously reserved for non-genotoxic carcinogens.

Another case that presented difficulties was benzene, a chemical evaluated twice by the Council (7,8). Neither the first nor the second assessment could resolve the problems encountered in this special case. Benzene has been shown to cause acute non-lymphatic leukaemia in humans and to possess genotoxic properties. However, the genotoxicity tests and research into its interaction with DNA have demonstrated that benzene reacts differently to other genotoxic carcinogens. The reason for this is unclear. It has not been possible to determine whether or not benzene has a stochastic mode of action. On the other hand there were high-quality epidemiological data showing that the leukaemia risk is not increased at concentrations even higher than the ones people are generally exposed to. Therefore, it was considered likely that the exposure-response curve would be sub-linear rather than linear in the range relevant for the extrapolation and that linear extrapolation would produce too low a result. The first assessment offered the solution to apply linear extrapolation and to increase the resulting concentration 100-fold. The major conclusion of the second assessment was that the mechanism underlying the carcinogenicity was still poorly understood, while the epidemiological evidence for lack of greater risk of leukaemia at relevant concentrations had
become stronger. This was due to data from an unusually large cohort exposed to low levels. And the figures lend support to the assumption of sublinearity of the exposure-response curve in the relevant range. It was not possible, however, to derive the exact configuration of the curve using the available data. The concentration at which no enhancement of the leukemia risk was observed is approximately three times greater than the TBREL calculated in the first evaluation. Accordingly, the original figure was still considered sound.

Finally, quartz appeared not to fit into the classification system (9). It is another genotoxic carcinogen demonstrating unusual properties. Quartz presumably induces tumours through long-term irritation of the tissue and subsequent formation of exocyclic DNA-adducts in the target organ, the lung. Thus, the interaction with the DNA is indirect, though occurring through a mechanism different from that of cadmium and arsenic. Quartz was designated as a carcinogen with a non-stochastic genotoxic mode of action, implicating that its carcinogenicity is characterised by a threshold.

CONCLUSIONS
The experience gathered confirms the conclusion in the updated guidelines that the original approach to establish exposure limits for carcinogens is too rigid. The lesson learned is that genotoxic carcinogens are more heterogeneous than assumed originally. In some cases they can be treated like non-genotoxic ones, in others the evidence implicates that less orthodox methods are required. The appropriate solution is more flexibility. We expect this to be reflected in the Council's future recommendations for calculation of TBRELS.

REFERENCES
TRACK 3

SESSION 1

RISK COMMUNICATION

- METHODOLOGY
RESTORING TRUST BY PARTICIPATION: A Comment Based on Social Judgement Theory

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ABSTRACT
The concepts of trust and credibility are very much in focus of much of today's research on risk issues. It is generally accepted that without trust in those involved in risk communication, there can hardly be any good dialogue between experts/governments and communities. Paul Slovic has, among others, suggests that restoration of trust may require openness and involvement with the public that "goes far beyond public relations and two-way communication". Specifically, it is suggested that the public has to be given some power and participation in the decision making. In this contribution, it is argued that the framework of Social Judgment Theory, SJT, could give some ideas to why public participation could restore trust. SJT is based on Egon Brunswik’s lens model and has been developed to study human inference behaviour, that is, when there is uncertainty in the tasks. In many respects, risk perception is a parallel to judgments under uncertainty. By participation in real risk or decision settings, people can gain knowledge about three task/situation aspects of importance for trust and credibility: 1) How much uncertainty is there in the task itself? 2) Which relevance do the information given have? and 3) How uncertain am I in my judgments? The underlying assumption in this contribution, is that trust and distrust (in particular) is very much about inferred motives. You distrust a certain person because he/she has proved to be untrustworthy or because you suspect that his/her risk view depends on some hidden motives you can not see or that the person denies. Taking part in decision making involving risks, will show that tasks involving uncertainty are very difficult to handle and that people might have good intentions and still fail to perceive or judge the risks correctly. Trust can be restored (at least to a certain extent) when the hypothesis about hidden motives can be rivalled by a hypothesis about cognitive strain and probabilism in the task.

BACKGROUND
In focus of much of today's research interest in risk communication, is the fact that the communities do not trust policy and decision makers such as politicians, government or industry people. This is especially serious in the years to come when we are expecting risk issues concerning for example the nuclear industry, global warming and hazardous waste, to be even higher on the political and social agenda all over the world. Despite the research efforts devoted to trust, society needs an in-depth understanding of trust for conducting successful communication regarding environmental hazards.

In the psychologically/sociologically oriented literature, there are many definitions of the concept of trust to be found. Depending on the discipline, trust can be attributed different functions and dynamics (for an introduction to the concept of trust, see Renn & Levine, 1991; Kasperson, Golding, and Tuler, 1992). However, trust as a psychological and sociological orientation relies in faith, which in turn involves emotions. In this contribution, we will
address the importance of motivation. Specifically, we put forward that trust is closely related to the motives attributed to the other part.

In a situation where risk is perceived/estimated/evaluated, one of the first questions raised (sometimes not so explicit), is whether the person, organisation, government, etc., can be trusted. Not seldom this means that we ask ourselves if the other part have any hidden motive for their conclusion about the risk at hand. This is specially valid if our perception of the risk differs significantly from the other part. Important to notice here, is the fact that we seldom interact/work with that other part when it comes to how this risk perception is formulated. We do not know the actual cognitive processes that came up with this risk judgment. But we tend to think that the processes are pretty much the same ours. A problem in this is that we generally have rather poor ideas about our own strategies in this respect.

This has in effect that we often tend to infer motives as the prime determinator of how other persons are perceiving/estimating/evaluating risks. Since we seldom participate in the judgments of these risks (here we are referring to risks that are processed on a social level), we can seldom be corrected if we are wrong in our inferences.

SOCIAL JUDGEMENT THEORY
One way to think of how humans perceive, assess and value risks, is to consider it to be a special case of human inference behaviour. That is, unless we do not have an algorithm for how to deal with a risky situation (and if so, it is doubtful if we have any risky situation at hand), the task is very much similar to that one of making an inference or decision during probabilism. In the vein of this thinking, it could be interesting to see if models and research from this field of psychology could contribute to modern view of risks.

In this paper, we want to suggest Social Judgement Theory (SJT), as a means of understanding how trust could be restored. This theory is based on the conceptual framework Brunswik’s lens model (Brunswik, 1952). One of Brunswik’s students, Kenneth R. Hammond developed the model to be used in general inference behaviour. For more extensive readings concerning SJT. see Hammond, 1955; Hammond et al., 1975, Warg, 1983. Here, suffice it to give a brief outline of the basic concepts in SJT, and the thinking that could be of importance for trust and risk research.

The psychology Brunswik wanted to advocate was a functionalistic psychology with the nature of the organism’s adaptation to its environment. This way to focus on the interaction between organism and environment is indeed relevant for a psychology of cognition. Specifically, the usefulness of this thinking is clear if we define cognition as a knowledge process and knowledge to more of a relation between the organism and an environment to be known, than a state of the organism.

The analytical method employed by SJT and providing a measure of the subject’s adaptation to the task, is the lens model equation. A commonly used version of this equation is as follows:

\[ r_a = G R_e R_s \]

Where \( r_a \) is the correlation between the values of the judgment and the criterion, \( G \) is the correlation between the linearly predictable variance in the task system and the cognitive system, \( R_e \) and \( R_s \) are the linear multiple correlation between cues and the criterion and the judgment, respectively.
QUASI-RATIONALITY
Several decades of research on human behaviour in probabilistic inference tasks, can account for a number of stable and sometimes intuitively unexpected results (for a summary of this research, see Brehmer, 1980). For instance, it has been found that there is a contradiction between what the subjects say they do and the analyses of their actual behaviour. Subject show great inconsistency when trying to follow a functional rule, even easy ones as positive linear functions. Even if the correct functional rule is told, that is no insurance that correct responses will follow. Findings has also revealed that the consistence of subject’s strategies is a monotonic function of the predictability of the task. That is, the more uncertainty the task has, the more inconsistency is shown by subjects in following the correct rule.

The studies in this field, show that probabilistic tasks of the kind used, tend to encourage subjects to adopt a thinking that is partly rule bound, to some extent random, but also one that subject’s only have insight in to a minor degree. This type of thinking is called quasi-rational thought and is thus seen as a mixture consisting of intuitive and analytical components. This quasi-rational thinking can be an important concept when studying and trying to explain interpersonal conflicts.

In this paper, we will use quasi-rationality as an important concept possible to apply in the discussion of trust and distrust between people’s risk perception. The nature of many (if not all) problems/questions/issues involving risk, is probabilistic in their characteristics and thereby very difficult to perform well in. In addition, and of great signification in this context, it is very difficult to gain insight in the strategy one is using and hence, it is almost impossible to explain to another person how, what, and why you are doing something. If this reasoning has any bearing, it is easy to understand why distrust never is far away in risk debates.

PARTICIPATION AND TRUST
The lens model equation indicating the requirements for optimal performance in a probabilistic inference task, \( r_s = GR \), can also give a clue to what conditions that could improve or restore trust among people. Without going into any details, the equation could also be written as \( \text{performance} = \text{knowledge} \times \text{cognitive control} \times \text{task control} \). Still another way to write the equation is to formulate three questions that are crucial for good performance in probabilistic tasks: 1) How much uncertainty is there in the task itself?, 2) Which relevance do the information given have? and 3) How uncertain am I in my judgments?

In this paper, we suggest that trust can benefit (and maybe be restored) from understanding of how difficult probabilistic inference tasks are. A way to gain this understanding is to participate in the processes where the judgments of risk are made. We are fully aware of all the difficulties that may be at hand for this, but we want to address the question at least on a principle level.

We put forward the following discussion: To perceive/assess/evaluate risky situations can be seen as special cases of making decisions under uncertainty, that is, the tasks contain probabilism. From an extensive amount of research on human inference behaviour, we know that people perform rather poor, have far from full insight in their inference strategies, and consequently they are bad in explaining their strategies to others. This given, no wonder why people may distrust other in judgments about risks. People tend to focus on the motives for the risk perception/assessment/evaluation rather than on the restrictions in the cognitive processes.
A way to gain knowledge of the hard task to achieve when performing on probabilistic tasks, is to try them yourself. If you do so, you will get an idea how that there is a certain amount of uncertainty in the task which makes it understandable why other people have problems with making risk estimates of different kinds. Likewise, performing on this type of task will most certainly tell you that you do not have all the information given for optimal performance. In addition, you will maybe get an idea of how uncertain you are in your judgments. All this will tell you that since you find these tasks difficult, others might have the same problems.

Thereby, it is highly possible that instead of focusing on the motives of other people in statements about risk (which often is no more then speculations and guesses), you understand the cognitive strain these tasks put on people. Consequently, focus is moved to cognition and the characteristics of the task rather than more or less hidden motives, and this is a significant step towards increasing trust in the other person.

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SAFETY AND INTER-ORGANISATIONAL COMMUNICATION
A STUDY OF INTERFACES IN LARGE SOCIOTECHNICAL SYSTEMS

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ABSTRACT
This paper discusses the effects of inter-organisational communication- and power patterns on safety in loading operations between offshore rigs and supply vessels in the oil-fields of the North Sea. The paper also includes some methodological suggestions on how to approach these kind of problems. The paper is based on a study of the workload of bridge personnel and safety onboard supply vessels in the North Sea (Serck-Hanssen 1998).

The study reveals a constant negotiation between actors concerning safety levels vs. economical priorities. A specific case is linked to who decides when the weather conditions are to harsh for loading operation. The actors are representing different companies, have different economic interests and are in uneven power relations. There are also possibly a lack of mutual understanding of the others position. These aspects of the inter-organisational interfaces must be understood and addressed in the strive for safety in a large sociotechnical system such as the offshore industry in The North Sea.

The methodology of the study was participant observation with interviews in context, i.e. the researcher was onboard and could observe the work, and evaluate the observations with the crew immediately. This is important as many of the dilemmas the practitioners are facing are visible only through daily praxis. This methodology also gives the opportunity to discover who the relevant actors in the risk prone processes are, from real life situations.

THE CASE
During a fieldwork onboard platform supply vessels (PSV) in the Norwegian oil industry, I witnessed several so-called unwanted incidents, fortunately non of which led to serious accidents. I will describe shortly one of them, which highlights the relevance of organisational interfaces in safety issues.

The official incident report goes approximately like this:

During unloading [of chemicals with hose from the ship to platform X], the wind increased to 50 knots with more than 60 knots in the gusts. As we had the wind at 55° the ship could not longer keep its position, so we drifted and the hose broke. We gave immediately order to the crane [onboard the rig] to retrieve the hose before it broke, but the crane was busy bringing down back-load. No pollution.

Nothing more serious happened this time, but similar incidents have killed people, when high pressurised hoses have started to beat uncontrollably. It was a situation out of control, and with a little less luck, it could have turned into a serious accident.

It is an unusual situation for a safety researcher to actually witness a potential accident in its making, and it gives a rich material for analysis. The data from the whole context is much richer than what possible can be revealed from post-accident investigations. I will come back to the methodological reasons for this. I will give an ethnographic "thick description" (Geertz 1973) of the incident and its context, to show how this potential accident was result of a complex organisational structure and not barely result of simple misjudgement by the captain of the ship, or bad luck with the weather. To understand the decisions made by the actors and putting them in the situation described above, I follow Rasmussen ...

making cannot be separated form simultaneous study of the social context and value system in which it takes place and the dynamic work process it is intended to control. (Rasmussen 1997(p.188))

I will try to explain why the captain of the supply vessel started the unloading-operation during such harsh weather conditions, and why he did not stop the operation earlier. Also the decisions during the event does, as I will show, deserve some attention.

PRACTICAL CONTEXT
The PSV's usually do 4-5 days roundtrips to several platforms belonging to a number of oil companies, unloading different supplies and chemicals, and bringing to shore waste of different kinds. These supplies are necessary to keep the oil production and drilling operations going, if the platforms don't get what they need, operations have to stop. The economical costs of stopping operations are of course enormous. During winter the weather can be very rough for long periods, making it difficult or very dangerous to supply the platforms. The platforms can therefore run the risk of running empty of vital supplies, for example chemicals used in drilling operations, or drill pipe sections.

The unloading itself take place as the PSV is lying very close to the platform, maybe 10 meters from the leg, and it is kept steady by the bridge officer steering several propellers and thrusters. The crane on the platform lift the containers of the open cargo deck, and hoses from the platform are attached to tank outlets on the ship. On the cargo deck the seamen are working on hooking containers and other cargo on and off the crane's hook. The bridge officer, the crew on deck, the crane operator and the platform control-room officer communicates by radio. The loading process is a quite complicated operation, that may last from a few hours to one day.

COURSE OF EVENTS
In this particular case the weather was very bad already when the PSV left port. When the vessel arrived the first platform the captain decided that the weather was to bad for unloading, and started to wait at a safe distance to the platform. The platform officer expressed an urgent need for some chemicals for drilling, and the ship's captain was requested to start unloading as soon as he possibly found safe. Onboard the ship this massage was met with some irritation, the officers wondered why the platform didn't keep their tanks full in the stormy season, since they should know it could be difficult to get new supplies. It was also a slightly irritated atmosphere due to the waiting itself. It is very tiring to be out in the storm, and every day idling means one day more before they could come back. So there was a certain pressure to start unloading as soon as possible, both from the platform and the ship.

When the wind decreased down towards 40 knots, the captain decided to start the operation, and he informed the control-room on the platform. Shortly after the PSV was close to the platform and ready to get the hose. It soon became clear that the crew on the platform was not ready, which caused much irritation onboard the PSV. It took more than 30 minutes before the hose was onboard. In the meantime a few containers was unloaded, but the work was not efficient. The captain onboard did not complain about this to the platform crew, but he had beforehand asked them to be ready, and only load chemicals which were most urgent, not containers since it was uncertain how long the acceptable loading conditions would last when the storm temporarily calmed down. After a while the wind increased again and the bridge officer had more and more difficulties keeping the ship in position. He then stopped the high-pressure unloading-pumps, and asked the crane to pick up the hose. The deck crew went out on deck to release the hose and hook it on the crane. The crane however, did not come...
immediately, but waited several minutes. It also brought down a container on deck, close to the unprepared deck crew, which itself is against safe practices, and quite dangerous in high seas. It was then too late to save the hose, and the crew had their hands full releasing the container before the ship drifted too far away.

What happened really during this operational sequence? I will try to give an answer to that through an analysis of the situation in context.

**CONTEXTUAL ANALYSIS OF OPERATION**

Unloading of a PSV is an joint operation between two organisations with a lot of coordination relying on efficient communication. It is also an interaction between social groups with different economical interest and risk potentials, but also strong interdependencies on different levels. Although they are interconnected, I will single out these interests, risks and dependencies, and see how they have effects in the course of events. Then I will try to show how lack of mutual understanding of each other’s situation had influence on the development of the situation.

*The economical interests:*
The platform organisation has some very clear interests, foremost is it to get their supplies when they need them, and with as much flexible service from the PSV as possible. This service can, as in this case, be very economically important. The ship and its owning company have no immediate economically interests in the operation itself, they have a long term contract, and make the same money whether they can unload or not. On the other hand they want to renew their contract and keep a good relationship with their charterer. The officers onboard were quite concerned about this. They do not want to be seen as “difficult”. Also, for different psychological reasons, they want the job done.

*The different risks:*
The platform organisations main risk in this situation is mainly economical. It has been incidents were PSVs has hit platform legs and damaged them. In this case the operation was done at leeward, so when the ship lost control it drifted away from the platform. On the ship the risk of personal injury is higher. The deck crew are running between loose containers in high seas and are close to strong forces when they work with the crane-hook on a heaving deck. There has been several accidents with severe injuries and deaths on PSVs deck. The types of risks the two organisations are running are thus of different orders, so to abort an operation will increase the economical risk of the platform organisation while it decreases the accident risk on the PSV, and vice versa.

*The dependencies:*
The long term economical dependencies are obvious, the platform needs supplies, and the ship needs employment. In the operation itself there are several dependencies between actors, regarding co-ordination of a complicated task. Between the platform control-room, the bridge officer on the PSV, the crane operator and the PSVs deck crew there are radio contact. The positioning of the boat, the order of cargo unloading, and instructing the crane and deck-crew are information and decisions that has to flow accurately between these actors, and mutually understood.

In the case described, all these element are interacting in the situation. The platform organisations economical interests and the PSVs relational interests and economical long term dependencies are backgrounds for the decision to start operation in weather conditions near
the limitations of the ships controllability. When operation starts it is clear that the platform crew have little insights in the risks on the ship. The fact of the delay at the beginning, and the fact that the crane-operator took time to unload another container when the situation turned critical on the deck of the PSV shows to things. They are different places and seeing different risks, and they fail to understand that they don’t see the same things. The PSVs crew took it for granted that these risks were understood on the platform, and were angry at the platform crew, but they did not express their reasoning behind their decisions to unload very quickly, and their request to stop unloading immediately when the weather turned bad again. Shortly, they take common decisions without common goals, information and communicative presuppositions.

GENERAL LESSONS
Due to little time and space here, I have only given a very short analysis of a "could-be accident". What does it teach us, on risk prevention and safety research?

The problem observed here is related to organisational interfaces, or more precise the fact that people in different positions develop different viewpoints from which they take their decisions. When those who have the risk potentials are dependent of others with no or other risk potentials, lack of mutual understanding and under-communication can lead to dangerous or unwanted situations. One simple answer to parts of this problem is increased communication, an answer also given by Grabowski & Roberts (1996). It also raises the question of safety vs. economical priorities as negotiable issues between different sub-systems of a larger sociotechnical system. When each subsystem has its own economical goals, it is my hypothesis that overall policies regarding safety will be harder to implement. This topic is of special relevance for the future as subcontracting and increased outsourcing to allow higher flexibility are organisational trends today.

On another level the case has some methodological lessons for research. The incident was studied qualitatively, "in the making", giving a very rich context, much richer than revealed here. Much of the analysis is based on comments of the situations by the actors themselves, during the development of the situation. It was also possible to understand the incident in the light of daily practices, which was the original objective of the fieldwork. As a safety researcher it was more than interesting to see that during 12 days onboard PSVs I witnessed 3 situations that could have developed into possible accidents, including the most serious one described here. (The other two, one related to several engine blackout on a platform crane, and another to wrong loading of drill pipe sections from the land base, shows the same problem of communication failure, interdependencies, and lack of mutual understanding of different actors risks.) As an outsider one see things different than those socialised into the everyday life of the organisation studied, and can see and question practices taken for granted. (See (Vaughan 1996 p.417 for a discussion of this old anthropological truth in safety context). My argument is that risk analysis also must be analysis of daily practices, done by outsiders. This give a different tool for understanding than most common accident reports which very often focus on single causation and juridical responsibility. Through this methodology is it possible to reveal the complex decision environment the actors work in when they make decisions behind accidents, decisions so often written of as "human error". Understanding this environment is the first prerequisite for any attempt to redesign it.
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RISK MESSAGE VERSUS RISK COMMUNICATION PROCESS REGARDING RISK COMMUNICATION ON CHEMICAL INDUSTRIAL HAZARDS

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ABSTRACT

The European Directive regarding the management of chemical accidents emphasises the central role of risk communication in the prevention and mitigation of consequences of a chemical accident and identifies the public participation as an essential requirement in order to make effective the information initiatives addressed to the population.

At present, the information model adopted in Italy seems to satisfy only partially the Directive requirements. The information is addressed by the source to the audience, according to the traditional, authoritative model which assumes that the information provided can satisfy information needs of population coping with the consequences of a chemical disaster. Besides, the model in force seems to privilege the technical content of risk message, disregarding other risk communication issues necessary for planning an effective information. These issues should include the knowledge of risk perception and information needs of the population; the need of population to have confidence in the ability of officials responsible for risk management; the necessity to build a continuous information process that can be adapted to the changing needs of the audience; the promotion of public involvement in the decision making process. Critical considerations on the information model adopted in informing people on major industrial hazards are supported by the results of a study carried out in Italy in two different industrial areas, where local authorities planned information initiatives according to the law requirements. In order to evaluate the effectiveness of local information initiatives we analysed the impact of risk communication on population samples exposed and not exposed to the consequences of a chemical accident.

PREMISE

People’s right to be informed on technological risks has been sanctioned in the last twenty years in numerous laws and regulations adopted in the industrial countries, in order to enhance health and environmental quality. At the same time, numerous studies (2, 3) were carried out in order to elaborate strategies and procedures suitable to find solutions to difficulties affecting the effectiveness of risk communication initiatives aimed at:

1. increasing the consciousness of risk among the population liable to be affected by adverse effects produced by the risk factor;
2. facilitating the adoption of protective measures and safe behaviours in order to cope with risk consequences.

For example, two European Directives analysed in depth all aspects of risk management regarding major accident hazards, including risk communication issues.

ITALIAN EXPERIENCE ON RISK COMMUNICATION

With reference to risk communication regarding major chemical hazards, only recently, new regulations guarantee in Italy the implementation of risk information addressed to the population who might be affected by the consequences of a chemical accident occurring in a chemical plant.
The informative procedure, adopted by Italian law, follows the traditional information model according to which, information must be addressed by the source to the target. Technical information on risk regards the substances utilised in the industrial processes or stored in the plant, their toxicological properties, accident scenarios that may occur in the plant and adverse effects on health of human beings and on the environment. Such information is provided directly by industry in order to overcome bureaucratic difficulties due to the risk evaluation procedures that in the past have delayed risk information.

The Mayor of the town, where the industrial activities are located, is the local authority in charge of risk communication in the Municipality addressing the information sheets to the population. More in general the Mayor, in his quality of public health authority, supported by technicians operating in the local health and environmental services, promotes all actions necessary to prevent the adverse effects due to the risks existing in the area. The Prefetto is the local authority responsible for emergency planning. He must provide information on mitigation measures and safe behaviours to adopt in case of accident. All this information is collected in an information data sheet, one for each industrial installation. The target population identified by the emergency plan is the people living in the area close to the industrial sites and potentially affected by the consequences of a major accident. Because of the long time taken by the bureaucratic procedures of evaluation of the safety reports, in many cases the emergency plans are available in a provisional form, causing some problems in defining the population potentially at risk.

At the present, law requirements request only the release of technical information sheets. In 1998, according to the law, information initiatives were carried out in all municipalities where major hazard installations are located.

Previous studies carried out in Italy pointed out difficulties in pursuing effective information initiatives regarding technological risks which are perceived as unknown, uncertain, catastrophic in consequences, and uncontrollable at the individual level. These factors induce in people at risk a need of safety that cannot be satisfied by the communication of mere technical notions on risk and prescriptive messages regarding safe behaviours to adopt in emergency phase (1, 2, 3).

Only now, as a consequence of the implementation of law requirements regarding risk communication, it is possible to verify the validity and the effectiveness of the information procedure adopted in our country. Some general considerations can be drawn starting from Italian studies recently carried out in order to verify the information model in force compared with a risk communication process that should be flexible and suitable to the information needs of population exposed to the risk factor consequences (4, 5).

**METHODOLOGY**

Two surveys were carried out on randomly selected samples of population living in two industrial areas where information initiatives regarding chemical industrial hazards were promoted by local authority according to the law requirements. Some differences characterised the two industrial areas selected for the study.

The first industrial area is located around Mantova, a historical and artistic town in the North of Italy. In the peripheral area of the town, are concentrated five chemical plants where major chemical hazards can occur. The population living in the Municipality is equal to about 70,000 citizens. 5,000 of them live in the area near the industrial plants and might be affected by the consequences of a chemical accident. In the period of July 1998, information sheets were released by the Mayor of the town to the families resident in the area exposed to the risk factor, as defined by the provisional emergency plan. In addition to the information data sheets, one for each potentially hazardous site, the responsible for information provided a
leaflet on chemical industrial hazards explaining risk issues treated in the sheets. The leaflet provides a general arrangement of the risk issues treated in the information sheets and some further information in order to facilitate the comprehension of the technical aspects. Special emphasis has been put on the emergency measures.

The second industrial area is located around Rosignano Marittimo (Livorno), a village on the coast of Mar Tirreno, in Central Italy. Here, only one chemical plant can be found and it represents the main productive activity in the area. The population of the Municipality is about 25000 residents. About three hundred people live or work in the area defined as potentially at risk according to the provisional emergency plan. In Rosignano, the Mayor of the town released information sheets to the whole community through a newsmagazine edited by the Municipality. In the past, information on major chemical hazards has been periodically addressed to the whole population through the same publication.

The survey in Mantova was carried out on two samples of population respectively selected among residents in the industrial area and in the city centre. This in order to highlight differences in risk perception and information needs deriving from the proximity to the risk source.

In Rosignano Marittimo, the population sample was selected from the residents of the whole Municipality, being all the citizens informed on major hazards.

In both areas, the study has been planned with the aim of evaluating, through questionnaires administered by trained interviewers, the following aspects of risk:

- risk perception of major chemical hazards compared with other risk factors existing at the local level;
- awareness and knowledge of major chemical hazards and risk related issues;
- identification of actions aimed at managing risk and mitigating consequences;
- identification of those responsible at different levels for risk management and mitigation of consequences;
- identification of safe behaviours to adopt in case of accident;
- comprehensibility and effectiveness of informative materials.

The results of the study are analysed more in detail in another paper presented at the meeting.

CONCLUSIONS

The results show no significant differences between the two populations involved in the study with regard to the effectiveness of information initiatives carried out in the two areas.

The analysis of data show the following aspects to be accurately evaluated for the future:

1. the high number of non respondents in both areas, higher in Mantova, motivated by indifference in risk issues and distrust in the initiatives promoted by public authorities;
2. a low number of respondents who state to have received information material;
3. distrust in the safety guarantee offered by the present regulations on major chemical hazards;
4. difficulties in identifying those people responsible for risk management and mitigation of consequences;
5. difficulties in identifying safe behaviours to adopt in emergency phase;
6. need of population of trustworthy relationships with technicians and professionals according to their competence in managing risks, familiarity and their independence from special interests regarding the risk factor.

Results show differences in people perception of major hazards with regard to other risk factors existing in the two communities. For example, in Mantova people are most concerned by air pollution, on the other hand most of the population in Rosignano perceives major industrial hazards as the highest severe risk. The differences probably depend on the quality
of the relationships existing between population and local government and population and industry in the different areas considered in the study.

In the village of Rosignano Marittimo, industry produced benefits for all the community, not only on the occupational level, but also building structures of public interest (houses, school, hospital, church, stadium, theatre) and promoting as well leisure activities. Besides, the industry management showed interest in reducing risks for the population. At the same time, local public administration was able to build and maintain a continuous dialogue with the community about health and safety problems.

From a social and economic point of view, the community of Mantova seems to be more heterogeneous. It shows a higher conflict level with the industry that produces pollution and with the local public administration that neglects the fear, regarding health and safety, of citizens who feel threatened by the industrial risks.

As regards the effectiveness of information, the adopted informative procedures focus the attention on the risk message, assuming that information provided satisfies information needs of population coping with risk. The information is addressed by the source to the audience using a traditional authoritative model, which does not suggest any interaction between the public and the source.

In both areas, information initiatives do not seem to have modified the consciousness of the population regarding major industrial hazards. Results referred to the various aspects considered in the interviews, seem to confirm the ineffectiveness of information released in a prescriptive way, disregarding risk perception and information needs of population. Initiatives planned in order to satisfy the prerequisites of the law do not modify opinions and attitudes regarding risk, notwithstanding the level of confidence put in the communicators by people.

From the information model provided for by law, some considerations can be drawn:

- the information necessary for increasing people consciousness of risk is identified with poor technical notions on risk, not easily understandable by an audience heterogeneous for perception and education;
- the emergency information is identified with poor safety prescriptions on behaviours to adopt for coping with risk consequences.

The model, in fact, does not provide the involvement of population in the decision making process, that would be the only actual guarantee of obtaining the prefixed objectives. Only a continuous communication process, to be developed at the local level, would obtain an increase of consciousness of risk and, consequently, the development of a correct attitude in case of emergency. The model should be based on the following:

- the correspondence of information released to real information needs;
- people trust in those authorities and professionals in charge of risk management;
- people participation to decision making process.

Regarding the first point, risk message must be included in a communication context, flexible, wide-ranging and well constructed on the basis of population needs regarding safety and health. Regarding the second issue, trust is a prerequisite in order to gain effectiveness of information. Study results show that people identify as trustworthy those professionals who actively operate in the effective management of risk. Information initiatives promoted by public authorities can achieve the prefixed goals, only involving technicians and professionals recognised by people trustworthy for their competence, familiarity and neutrality regarding the risk factor.

Besides, the information process should include participatory procedures suitable to the needs of the local community, at least as concerns the emergency planning. The study results confirm that information released through information data sheet or other material cannot
modify itself erroneous attitudes in coping with risks. Major industrial hazards do not frequently occur, but the accident consequences can be catastrophic. Consequently, such a hazard requires a careful attention from the public authority in pursuing awareness of risk in the population and their capability to react properly in case of accident.

The Mayor of the town, presently responsible for the distribution of information sheets to the population, should have also the task of promoting the information process. He could coordinate different interlocutors involved in risk management and communication. He should also promote at the local level participatory procedures making people an active part of the decisional process, creating the premises to gain the public trust and reinforce the role of the local authorities, achieving the objectives recommended by the European Directive.

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IN THE NEIGHBORHOOD:  
EXPLAINING THE LOCAL OPPOSITION TO THE SITING OF WASTE FACILITIES IN THE NETHERLANDS

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The siting of technological and industrial facilities such as railways, airports, power plants and waste facilities often generates opposition among local host communities. Central focus of this paper is the siting of waste facilities in the neighborhood, and factors which influence opposition to the siting of these facilities. A theoretical framework will be presented which explains neighbors' reactions to the siting of a waste facility in the neighborhood from psychological variables derived from the theory of reasoned action and its various modifications, from theoretical notions from literature on risk perception, and from social justice theory. Integration of these theories into one theoretical framework is considered important since the examination of the mutual relations between constructs from the three separate theories provides supplementary value toward explaining the behavioral intention to act against the siting of a waste facility in the neighborhood. In this paper, empirical data will be presented, and it will be shown that an integrative model explaining the behavioral intention to act against the siting of a waste facility in the neighborhood was successfully constructed and fitted to the covariance data from neighbors of a waste incinerator in operation, neighbors of a waste facility under construction and residents not living near a waste facility.
TRACK 3

SESSION 2

RISK PERCEPTION KNOWLEDGE TRANSFER & EVALUATION
"TRACK 3
Session 2
RISK PERCEPTION
KNOWLEDGE
TRANSFER & EVALUATION"
THREE THEMES IN RISK PERCEPTION:
TOWARDS A CONCEPTION OF RISK PERCEPTION AS IDEOLOGY RATHER THAN EMOTION

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ABSTRACT
This paper describes empirical work on risk perception and some related dimensions, in particular with regard to radiation and nuclear power hazards. Most of the data cited come from a current CEC project in which 5 countries in Western Europe have participated. Risk is seen to be a primary factor in many policy matters and clearly, to the public, more important than utility considerations. Previously formulated models have been found to be deficient and a much more efficient alternative is suggested. Trust is finally found to be moderately strongly related to risk perception, but only when defined in a specific manner to the hazard studied. These results point in the direction of an ideological interpretation of risk perception, in opposition to the received view in which risk perception is seen as the reflection of ignorance and emotion.

The present paper is based on work in a project sponsored by the European Commission in its 4th research framework http://www.move.to/riskpercom. There were five partners: IPSN, France (Dr. Jean Brenot), NRPA, Norway (Dr. Jon Reitan), Ciemat, Spain (Dr. Ana Prades), CRR, Sweden (Professor Lennart Sjöberg, coordinator) and IFR, UK (Dr. Lynn Frewer). The purpose of the project was to enhance understanding of risk perception, especially with regard to radiation and nuclear hazards, and some related policy problems, such as HLNW repository siting. The project has produced many interim reports and publications, see note 2 for the address of the web site where full documentation is available and continuously updated. In the present paper I will only give brief discussions of selected themes from this work, and will base it mainly on my own work, focusing on risk perception. The data used here were all collected in the spring of 1999, and are from a mailed survey distributed to a random sample of the Swedish public, 65% response rate, 444 respondents. A full account of the study is available (1, 2), here I give only selected highlights.

Theme 1: The hegemony of risk

Just how important is perceived risk, as compared to benefit? A simple answer to this question is provided by a study of attitude, and modelling attitude in relation to perceived risk and

1 This is a study within CEC project RISKPERCOM (Contract FI4PCT950016), supported also by the Swedish Council for Planning and Coordination of Research (FRN), the Swedish Council for Humanistic and Social Science Research (HSFR), the Swedish Nuclear Power Inspectorate (SKI), and the Swedish Radiation Protection Institute (SSI).

2 The project's acronym is RISKPERCOM. It is fully documented on its homepage
benefit. Ratings of attitude to 7 energy production systems were regressed on judgments of risk and benefit of these systems, see Table 1.

<table>
<thead>
<tr>
<th>System</th>
<th>0, risk</th>
<th>0, benefit</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>-0.474</td>
<td>0.137</td>
<td>0.255</td>
</tr>
<tr>
<td>Coal</td>
<td>-0.544</td>
<td>0.071</td>
<td>0.294</td>
</tr>
<tr>
<td>Nuclear power</td>
<td>-0.692</td>
<td>0.192</td>
<td>0.608</td>
</tr>
<tr>
<td>Oil</td>
<td>-0.552</td>
<td>0.075</td>
<td>0.297</td>
</tr>
<tr>
<td>Natural gas</td>
<td>-0.681</td>
<td>-0.036</td>
<td>0.474</td>
</tr>
<tr>
<td>Bio mass</td>
<td>-0.567</td>
<td>0.136</td>
<td>0.328</td>
</tr>
<tr>
<td>Wind</td>
<td>-0.492</td>
<td>0.217</td>
<td>0.283</td>
</tr>
</tbody>
</table>

It is clear that perceived risk carried a much larger weight in accounting for attitude than benefit. Similar considerations arise in many situations, e.g. in attempts at siting a HLNW repository (3). Risk is more important than benefit. No wonder that politicians get more and more concerned about risk (4).

**Theme 2: Tampering with nature**

The psychometric model of risk perception (5) explains only a minor share of individual differences in risk perception, about 20% (6). I have elsewhere shown that it may be greatly improved by introducing a new dimension, *viz.* Tampering with Nature (7). Replications are clearly called for, as well new items. In the present study, I included 14 new psychometric type risk dimensions and 17 from the literature (8). The new dimensions were pooled to three indices:

- Tampering with Nature (includes aspects of morality)
- Consequences (both health related and economic)
- Problematic nature of risk, i.e. if the hazard creates a difficult and important problem

The traditional risk dimensions were also pooled to three indices:

- New and little known risk
- Involuntary risk
- Familiarity with risk

The questionnaire also included two items traditionally used to measure dread, such as "I strongly fear the risk". However, these items are about the respondent's emotional reactions to the hazard, not about the properties that he or she attributes to it. I therefore prefer to treat them as dependent variables and pooled them to an index of Dread.

For the present purposes, I analyzed the ratings of general and personal risk of nuclear waste, performed on 8-step category scales. A policy item was used as a third dependent variable ("The risk should have been avoided") and Dread was used as a fourth dependent variable. The six indices based on traditional and new risk items were entered in two stages in the
analyses. First, the three traditional dimensions were entered and proportion of explained variance estimated. Second, the new dimensions were entered and the increase of explained variance and beta coefficients of all of the explanatory variables estimated. The results of the regression analyses are given in Table 2. The significance of the increase of explained variance was also determined by means of F tests (9). The amount of explained variance was increased from about 0.2 to 0.4, significant in all cases.

<table>
<thead>
<tr>
<th>Table 2. values for risk dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk dimension</strong></td>
</tr>
<tr>
<td>New risk</td>
</tr>
<tr>
<td>Involuntary risk</td>
</tr>
<tr>
<td>Familiarity</td>
</tr>
<tr>
<td>Tampering with Nature</td>
</tr>
<tr>
<td>Consequences</td>
</tr>
<tr>
<td>Problematic risk</td>
</tr>
<tr>
<td>Variance accounted for by traditional items</td>
</tr>
<tr>
<td>Additional variance accounted for by new items</td>
</tr>
</tbody>
</table>

These results show clearly that Tampering with Nature is an important aspect of the nuclear waste hazard and that it adds a substantial amount of explained variance. This dimension has also been applied with similar success in other data sets and different hazards (10, 11), see also (12-14) for studies of concepts of "nature".

**Theme 3: Trust**

Trust has been implicated as an important factor in risk perception (15, 16). In the present study, the questionnaire asked for ratings of trust in the pertinent authorities for each of the 22 hazards. The trust ratings were correlated with general and personal risk. The over-all level of correlation was about 0.3 (somewhat higher for nuclear waste), or some 10% explained variance, in good agreement with data obtained in a previous study (17).

The three trust ratings regarding nuclear waste were pooled to a common index and used as an additional explanatory variable in regression analyses analogous to the ones reported above, with the 6 risk dimensions + trust as explanatory variables. The level of explained variance increased by 0.072, 0.059, 0.010 and 0.014 for general risk, personal risk, regret of risk and dread of risk, respectively. The $R^2$ values obtained for trust were in all 4 cases negative and significant: -0.296, -0.271, -0.112 and -0.135. The other $R^2$ values changed but little, but it should be noted that trust emerged as the variable with the largest $R^2$ weight for general and personal risk, somewhat larger than for Tampering with Nature.

The present data show that trust may be a moderately important factor in risk perception, supporting the conclusion I have published elsewhere (17). It is important to note that trust measures need to be made specific to the hazard under investigation since general trust, also
measured in the study, added very little to the explanatory power of trust - little but still something (1).

CONCLUSIONS
The importance of risk perception has been amply documented (1, 18), and is here well illustrated by the findings on attitudes. People seem to be moved by risk much more than by benefit or utility. This is clearly a fact to be reckoned with also in economic psychology. Risk perception is found to be strongly related to the dimension Tampering with Nature, and while worry (19) or dread also are involved they should be most appropriately treated as dependent on risk, not the other way round. Novelty of a risk seems to be of marginal importance. Opposition to nuclear technology is probably best conceptualized as being ideological rather than emotional. Finally, the importance of trust found here, and in several other of my studies, may seem to be less than expected. However, you may trust that an expert tells the truth, as he or she sees it, without believing that the ultimate last word has been said about a topic. Science develops, and what is true today may be a lie tomorrow. Tampering with Nature may in fact be something humankind does at its own peril, not a delusion by an uninformed public.

REFERENCES


As risk communication becomes more sophisticated, risk messages make increasing reference to concepts of uncertainty. Our research investigated both public understanding of uncertainty, and the impact of statements of uncertainty in risk communication messages on people's risk perceptions. We were also concerned with the impact of uncertainty on optimistic bias. Optimistic bias, where people believe that they are less at risk from a hazard than comparable other people, can represent a significant barrier to successful risk communication. The public may ignore risk communication messages, aimed at reducing risky behaviour, as they assume that these messages are directed at other more vulnerable individuals or groups. We investigated optimistic bias for five food hazards (BSE in beef and beef products, genetic modification of food, high fat diets, pesticide residues in food and Salmonella food poisoning) and found only some of the hazards were associated with optimistic bias; the results will be discussed. The effect of twelve different types of uncertainty on perceived personal risk and risk to other people, and respondents understanding of *uncertainty* will also be discussed.

This research was funded by the UK Ministry of Agriculture, Fisheries and Food.
ARE PROFESSIONAL RELEVANT RISK FACTORS TRANSFERRED TOWARDS LAYPERSON DURING CONSULTATIONS? THE CASE OF CANCER GENETIC RISK SERVICE.

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ABSTRACT
The convergence of genomic breakthroughs and of a societal involvement on risk management contribute to the development of specialized risk-based clinics like those involved in hereditary cancer. These consultations comprise with three aims: Perform risk assessment according to updated medical criteria Increase risk perception appropriateness Offer risk management options
The real respect of the freedom of choice needs a prerequisite, according to the French professional code of practice: a clear (plain), honest (faithful) and adjusted (fitted) information towards person (both patients and "unpatients"). It may be worthwhile to test if cancer genetic consultation reaches one of the previous quoted ambition: to improve risk perception. Indeed, many surveys underline the limitation, bias and pitfall of risk perception of which it may be emphasized: "Anchorage" with an inertia around the pre-consultation risk perception. The output (the risk perception-understanding post consultation) of information given by the physician (seen as an input) will be close to the a priori risk perception.
We shall present survey data analysis based on self-assessment of the risk of being cancer prone before and after a specialized consultation. It is shown that risk perception can be modified. Most importantly a cognitive re-construction of risk is built up after consultation. Lay persons seeking advice integrate with selective processes biomedical relevant factors associated with the risk evaluation.
To study meanings associated with changes is a necessary step for applied research on consultation output. Testing the "how" is as much important as testing the "how much".

INTRODUCTION
The convergence of genomic breakthroughs (1, 2) and of a societal involvement on risk management (3-5) contribute to the development of specialized risk-based clinics like those involved in hereditary cancer. These consultations comprise three aims: Perform risk assessment according to updated medical criteria (6, 7) Increase risk perception appropriateness. Offer risk management options (8, 9).
These consultations are, even if different, close to genetic counseling, and move in the general pattern of current patient-physicians relationship pattern, with emphasis on the value of autonomy. The real respect of the freedom of choice need as a prerequisite, according to the French professional code of practice, a clear (plain), honest (faithful) and adjusted (fitted) information towards person (both patients and unpatients).
It may be worthwhile to test if cancer genetic consultation reach one of the previous quoted ambition: improving risk perception.
Indeed many survey underline the limitation, bias and pitfall of risk perception of which according to the behavioral theory (10) it may be emphasized: "Anchorage" with an inertia
around the pre consultation risk perception, meaning that the output (the risk appropriation post consultation) of an information given by the geneticist (seen as an input) will hardly be modified from the a priori risk perception.

Geneticist capacity to change the pre consultation risk level could therefore be questionable and indeed many survey have showed that consultation lead to a modification of the risk level perception but with limitation (ref Claire).

The survey reported is not focus on the risk perception modification induced by the consultation but on the meaning of these changes. Particularly it was tested if the lay persons seeking advice at cancer genetic consultation had integrated the relevant factors associated with the risk evaluation.

METHODS

*Epidemiological and clinical relevant factors associated with the risk of being breast and/or ovarian cancer prone*

Four kinds of factors may be define

First the number of relatives affected with a disease belonging to the spectrum of the mutation (currently breast or ovarian cancer)

Secondly the genetic proxy (Measured in degree)

Thirdly the age at onset.

Population under survey

Five participating regional cancer centers who had more than 60 cancer genetic consultations by year were selected with a view to giving a representative picture of the French population as a whole (south: Marseille; north: Lille; center: Lyon, Paris, Curie, St. Cloud). Women were asked to participate when attending the cancer genetic clinics for the first time between January 1996 and December 1996. The protocol was approved by the “Commission Nationale Informatique et Libertés” . For that specific survey, out of 493 consultants were hold back only women disease-free attending the cancer genetic clinic for breast and or ovarian cancer prone condition.

Questionnaires

Before consultation, a standardized questionnaire was completed in the waiting room. The second questionnaire was mailed at home (with a stamped enveloped) during the week after consultation.

*Perceived personal risk of cancer occurrence* was measured on a relative risk scale “Do you think your risk of being struck by cancer is: nil, low, mean, high, very high, don't know”. For statistical analysis were analysis Low (nil, low and mean) versus High (high and very high).

*Medical characteristics and risk assessment by cancer geneticist:* After each consultation, a two pages closed item formularies was completed by the cancer geneticist about the content of the consultation. It gave details about the woman’s health, whether the she had any relatives with cancer and, if so, which organs were affected and the youngest age at onset in the family (first or second-degree relatives).

Hypotheses tested

Does risk perception (before and after the consultation) is related with

a) The number of women first degree relatives stroked by a cancer (with a positive association)

b) The age at onset (with a negative association).

For that analysis, women with relative struck by cancer before 18 years old (childhood cancer) were removed.
Sub-sample tested
The initial population under the survey was of 493 persons. Of them only women disease free and having at least one first or second-degree relative with breast cancer or ovarian cancer, were hold back (N=253).

Statistical analysis
The statistical analysis was carried out with the SPSS© version 8.0 statistical software. Significance of differences for contingency table was assessed by chi-square or Fischer's exact test when expected cell value was less than 5. For contingency table (2*3) Fischer's exact test was computed using the StatXact Package (Cytel Software Corporation).

We then adjusted the effect of significant variables, statistically significant at the \( p<0.05 \) level in bivariate comparisons, through multivariate adjustment. Stepwise logistic regression modeling was performed for that purpose.

Two explicative factors were tested: the youngest case of cancer observed in the family (first or second-degree relative). Since this parameter shows a bimodal curve, cases with age at onset lower than 18 were removed (childhood cancer) leading to a unimodal curve (data not showed). For the number of first degree affected with a cancer, a family (4 persons) with 8 cases makes the distribution curve bimodal, therefore the number of affected first degree had a ceiling of 4.

RESULTS
Before the consultation there is no statistical link between the perception of a personal high risk of cancer and the number of first degree with cancer, neither with the youngest age at onset. In contrast, after the consultation the risk perception is statistically related to both the youngest age at onset and with the number of affected relatives. The weight of the youngest age at onset being higher if analyze with a multivariate analyzes (table1). This "improvement", meaning a best fit with scientific pattern of risk construction, going with more women able to classify themselves in risk category. Indeed, before the consultation 15.8% of the sample were not able to answer to the risk self-perception question but after the consultation, only 7.9% of them were in the "don't know" category (\( p=0.006 \) OR 0.46).

Table 1 Dependant variable: Perception of the individual risk measured as high versus low (or normal) according to two biomedical explicative factors: Youngest age at the onset of cancer in first or second degree relatives (3 groups 20-29; 30-39; 40 and above) and number of first degree relatives with cancer (4 groups: none, 1, 2 and above)

<table>
<thead>
<tr>
<th>Individual cancer risk</th>
<th>Prior the consultation</th>
<th>Post consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of affected relatives</td>
<td>ns (( p=0.458 ))</td>
<td>p=0.021</td>
</tr>
<tr>
<td>Young age at onset</td>
<td>ns (( p=0.1976 )) *</td>
<td>p=0.0005*</td>
</tr>
<tr>
<td>Multivariate</td>
<td></td>
<td>Young age at onset p=0.01</td>
</tr>
</tbody>
</table>

COMMENTARY
Prior to the specialized consultation the self-perception of risk seems to be weakly if any related to "scientific" clues of hereditary cancer. After the consultation both major factors
(number of relatives struck by cancer and age at onset) were linked with the self risk-perception. Furthermore, from a medical point of view, for breast (and ovarian cancer) age at onset is more closely related to the risk of finding a mutation that the number of affected relatives. Indeed, according to Claus model (6) the probability of being breast cancer prone for a women 39 year old whose mother and maternal aunt had been affected with a breast cancer both of them by the age of 75 year is sevenfold lesser than for a women 39 year old with only one first degree relative affected by a breast cancer but by the age of 25 year. According to our results, this information, after the consultation, had been taking in account by women and in a multivariate analysis age at onset appears to be a stronger predictor of self risk-perception assessment than number of relative stroke by cancer. However the strength of the relationship assessed by the predictive value of the model is weak, meaning that other factors still interfere with the perception of risk. Cancer genetic specialized consultations modify the risk perception toward a more fitted model (according to "scientific norms") but, as a mean with a great inter-individual variability and according to the explicative weight, biomedical clues (or even evidence) are far from explain the risk perception as a whole.

REFERENCES

EFFECT OF CAUSAL STRUCTURE ON THE EVALUATION OF ENVIRONMENTAL RISKS

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Two evaluative aspects of environmental risks are distinguished: potential losses and ethical values. It is assumed that these two evaluative aspects arouse different specific emotions. Thus, two types of emotion are distinguished: loss-based emotions, e.g., fear, and ethical emotions, e.g., anger. Furthermore, it is assumed that the relative salience of these two judgmental aspects differs depending on the causal structure of the risk that is evaluated. It is hypothesized that ethical evaluation dominates if the environmental risk is man-made rather than natural, and that loss-based evaluation is stronger for threats to humans than for those to nature. In an experiment, scenario information about environmental risks was provided and the effects of (a) type of causality (man-made vs. natural cause; single cause vs. cumulative causation), (b) type of potential loss (harmful consequences for self, other people, or nature), and (c) geographical distance (close vs. distant) on ethical evaluation, evaluation of consequences, affective reactions, and behavioral tendencies were investigated. Results indicate that a risk's causal structure is related to evaluative focus, emotions, and behavioral tendencies. As hypothesized, it is environmental risks that are caused by humans, and those caused by a single human agent in particular, that are evaluated as morally blameworthy, that arouse ethical emotions such as anger, and that elicit aggressive behavior tendencies.

The Causal Structure of Environmental Risks -- Humans are Both Perpetrators and Victims.

Humans assume different roles with respect to environmental risks. On the one hand, most environmental problems are anthropogenic, i.e., originate from human activities. On the other hand, environmental damage can have perilous consequences for human health or living conditions. Hence, humans are both, perpetrators and victims of environmental risks (Kruse, 1995). Environmental risks can thus be seen from two perspectives: As risks for the natural environment or as risks from the natural environment (Böhm, Rost & Spada, 1998).

Thus, a causal chain going from human actions via environmental changes to negative consequences for mankind is typical for environmental risks. Different environmental risks differ with respect to which part of this causal chain they represent. Three basic types of environmental risk can be distinguished according to their causal structure: (a) ME-Risks (Man-Environment Risks), i.e., humans endanger the natural environment, (b) EM-Risks (Environment-Man Risks), i.e., an environmental change that is of natural origin jeopardizes humans, and (c) MEM-Risks (Man-Environment-Man Risks), i.e., an anthropogenic environmental change puts humans at risk.

Components of the Evaluative Process.

Cognitive Evaluation -- Potential Losses versus Ethical Values. Two evaluative aspects are relevant when evaluating environmental risks: potential losses and ethical values. Evaluation with respect to potential losses refers to risk perception in the narrow sense of the term, i.e., to the anticipation of potential negative consequences and an assessment how serious they would be (Yates & Stone, 1992). Ethical evaluation refers to the judgment whether any ethical values or principles are violated. Ethical considerations are relevant to environmental risks,
because they always affect other people or ecological systems, so that evaluation of environmental risks not only entails individual cost-benefit-analyses, but also ethical considerations such as social justice.

Affective Evaluation -- Loss-Based versus Ethical. Ecological risks arouse very intense emotional reactions, for instance anger, fear, or outrage (McDaniels, Axelrod & Slovic, 1995). It is assumed that both evaluative aspects -- potential losses and violation of ethical values -- elicit emotional reactions, but that different specific emotions result from these two aspects. Corresponding to the two evaluative aspects two types of emotion are distinguished: loss-based and ethical emotions. Loss-based emotions result from the subjective experience of riskiness, examples are fear and worry. Ethical emotions result from violation of ethical values or principles, examples are anger, outrage, and guilt (Ortony, Clore & Collins, 1988).

Behavioral Tendencies. Emotions motivate behavior, and different specific emotions initiate different types of behavioral tendencies (Frijda, Kuipers & ter Schure, 1989; Roseman, Wiest & Swartz, 1994). Loss-based emotions such as fear or worry may motivate people to prevent potential damage and may thus initiate pro-environmental behavior (Kannapin, Pawlik & Zinn, 1998; Martens & Rost, 1998). Ethical emotions such as anger may give rise to intentions to retaliation or punishment (Nerb, Spada & Wahl, 1998).

Hypotheses. It is assumed that the relative salience of the two evaluative aspects depends on the risk’s perceived causal structure, i.e., whether the risk is of type ME, EM, or MEM. These three types differ with respect to their causation in that they are either anthropogenic or of natural origin. The consequences of the three types differ in that they affect either the natural environment or mankind. Ethical evaluation is expected to be dominant when the risk is anthropogenic as compared to caused by natural processes. Correspondingly, ethical emotions such as anger and aggressive behavioral tendencies should be stronger when the evaluative focus is on ethical values rather than on potential losses. On the other hand, loss-based emotions such as fear, and preventive or remedial behavioral tendencies should be more pronounced when the focus is on potential losses rather than on ethical considerations.

METHOD.
Subjects. Four hundred participants, citizens of the city of Bremen, Germany, took part in the experiment, 59% were female and 41% male, their age ranges from 16 to 77 years (mean age: 33.61). They were recruited by advertisements in a local newspaper and paid for participation.

Independent Variables - Design. Three independent variables were manipulated: (a) Causation: natural cause versus anthropogenic -- cumulative causation versus anthropogenic -- single, identifiable agent. (b) Consequences: no negative consequences versus negative consequences for the natural environment versus negative consequences for other humans (children) versus negative consequences for the self. (c) Personal relevance, varied as geographic distance of the risky event: close versus far from the evaluating person.

Stimulus Material. Four fictitious scenarios were constructed. The core events in these four scenarios are: (a) A vulcano starts erupting gases and ashes; (b) a new gas arises in the atmosphere; (c) spores from new water plants accumulate in a river; (d) mosquitoes spread out in a new area. For each scenario several variants were constructed that correspond to the combinations of the independent variables. To illustrate the manipulation: The variants of the spores scenario read, for instance, that the river was either close to where the subject lives or in the Mid West of the U.S.A (geographic distance), the spores either stemmed from aquaria
or were carried to the river by water birds (causation), and resulted either in an interference with ecological balance or in health effects for children or for the self (consequences). Each participant evaluated one variant of each of the four scenarios.

Dependent Variables. The following dependent measures were obtained: (a) Evaluative focus, i.e., does the subject focus upon potential losses or upon ethical values as the relevant evaluative aspect? (b) Moral blameworthiness of the situation, (c) Perceived riskiness of the situation, (d) Intensity of several loss-based and several ethical emotions. (e) Behavioral tendencies for the behavior types help and aggression / retaliation.

RESULTS.
All results are based on multifactorial analyses of variance. Evaluative focus and moral blameworthiness depend on the type of causation of the risk. Ethical considerations are more important for anthropogenic causation -- both single and cumulative -- than for natural causation. The most morally blameworthy risks are those caused by a single, identifiable human agent. The second most blameworthy type of causation is cumulative anthropogenic, and natural causation is the least morally blameworthy.

Perceived riskiness varies with the the four scenarios and with the type of consequence. The vulcano scenario is seen as the most risky and the spores scenario the least, with the other two scenarios in between. More interesting is the consequence effect: Situations that afflict humans -- self or others -- are seen as riskier than situations with negative effects for nature, situations with no potential negative effects are seen as least risky.

Ethical emotions and tendency to aggression / retaliation are affected by the type of causation and the type of consequence. Both are more intense if negative consequences are possible -- be it for nature, others, or self -- than if no negative consequences are expected. With respect to causation, a single human agent arouses the most intense ethical emotions and aggressive tendencies, cumulative anthropogenic causation is second, and natural causes arouse the least ethical emotions and aggressive tendencies. This pattern parallels that of moral blameworthiness. Thus, anger and aggression covary with moral blameworthiness, but there must be some potential loss involved in order to evoke those responses.

Loss-based emotions and tendency to help depend on the type of consequence: Potential negative consequences for humans -- self or others -- evoke more intense fear and stronger inclination to help than negative consequences for nature. This consequence effect parallels that found for risk classification and perceived risk. Intensity of fear and tendency to help also vary with geographic distance, i.e., personal relevance.

DISCUSSION AND CONCLUSIONS.
First, there are remarkably few effects of the four semantic scenarios. Only perceived riskiness is affected by the scenario; thus, some situations are per se conceived as more risky than others. However, the model components and their relations are largely unaffected by the semantic underpinning.
Ethical evaluation is more salient when causation is anthropogenic than when it is natural. Moral blameworthiness is highest for a single human agent, higher than for cumulative anthropogenic causation. Natural causation is least morally blameworthy. Perceived riskiness depends on the potential consequences. Negative consequences for humans are perceived as riskier than negative consequences for nature.
As was expected, evaluative focus depends on the causal structure of the risk that is evaluated. Furthermore, moral blameworthiness goes together with ethical emotions and aggressive behavior tendencies. Perceived riskiness, on the other hand, which is a loss-based evaluation, corresponds to loss-based emotions and tendency to help. These results are in accord with the proposed theoretical model.

What was found in this experiment is an effect of the causal structure on all dependent variables -- evaluative focus, moral blameworthiness, perceived risk, emotions, and behavior tendencies. What remains to be tested in future studies are the hypothesized relationships among those variables. That is, do the causal relations go from evaluative focus to emotions to behavioral tendencies? That could be tested in a first step by applying structural equation modeling, a second step would be to experimentally manipulate emotions and to test the effects on behavior.

ACKNOWLEDGEMENTS.
I wish to thank H.-Rüdiger Pfister for numerous insightful discussions and many helpful comments on this manuscript.

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BIBLIOGRAPHY.
A DATABASE ON EXPERTISE IN CONSUMER PRODUCTS:
ENABLING RISK COMMUNICATION

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The clear impetus that consumer policies have taken in the last few years is a logical reaction to the evolution of the current society. Consumers demand more quality and safety in consumer goods and this fact generates an automatic reply at different levels: the governments, industry, specialised groups, researchers and other bodies involved in consumer protection.

There is, every year, a number of events related to consumer protection: conferences, congresses, workshops and fairs. The number of different issues tackled in these events is enormous, thus showing the complexity of the world of consumer protection. In addition, different countries and regions have a multiplicity of policies, legal systems, social and cultural traditions and institutional contexts. Therefore, there are many approaches to consumer protection issues depending on regional factors. For example, supranational organisations such as the European Commission have to face additional problems derived from the heterogeneous nature of consumer protection subjects.

Moving forward within such a complex framework requires the adoption of a clear strategy. One possible strategy for proceeding, is to deal with one of the specific aspects of consumer protection. The European Union, conscious of this reality, promotes the realisation of projects serving specific objectives.

Having considered the Council Directive 92/59/EEC on general safety of products, the Joint Research Centre and the former Consumer Policy Service (now Directorate-General XXIV) signed a collaboration agreement for the creation, among other things, of a data bank on safety of products. This data bank would:
- Contain a classification of consumer products and their potential risks of use excluding food products, live animals and chemicals;
- Cover institutes, laboratories, research centres and test and evaluation facilities having expertise in product safety;
- Establish for every facility, its capability, means, expertise, specialities, qualified personnel and the way to access its expertise.

Such a database is a tool, which is initially designed to complement the Community System for Rapid Exchange of Information on Dangers (CSREID). This system works as follows: the official authorities in Member States of the European Union give notice to the European Commission when a possibly dangerous product appears in the single market of the Union by means of the CSREID. When such a product is detected, in many cases it must be carefully tested in order to confirm its danger to potential consumers or users before any measure can
be taken (e.g. withdrawal of the product from the market). The intervention in the single market by the relevant authorities can have not only horizontal effects for consumers, by jeopardising the freedom of trade within the European Union, but also produce in-depth effects by affecting the commerce between Member States. To avoid these unwanted effects, but still enabling protection to the consumers, it must be clearly determined whether the product represents a hazard to the consumers or not.

The way the database on products, risks and experts complements the CSREID is by facilitating the task of finding those experts capable of giving an independent and reliable diagnosis in any field of the analysis (chemical, physical, metrological, standards and regulations, etc.) relative to consumer products. If the supposedly dangerous product is found to represent a risk to the consumers, the European Commission can take the corresponding measures.

This database was originally conceived as a helping tool for the Directorate-General XXIV (DG XXIV) activities, in cases of the introduction of a dangerous product in the market. However, the current situation, as was initially explained, has suggested an expansion to its use. Namely, the opening of the database for access to a fuller spectrum of possible users: other departments of the European Commission, the expert organisations present in the database, sectors of industry, consumer associations, etc. This enlargement can be carried out by the application of new technologies to the database (e.g. its deployment on the Internet).

Besides the initial purpose of the database on products, risks and experts for supporting certain Commission’s activities, the shift towards more consumer-oriented projects has been fully assimilated by it. As a consequence, the database has raised the interest of the experts in the analysis of consumer products, and also sectors of industry and several services of the European Commission involved in consumer protection.

This fact supports the idea that tools of this kind (implementation of policies through the use of technology) are valid instruments for the achievement of certain political objectives, particularly in the field of consumer protection.

Equally relevant is the idea of linking these kind of tools to others of the same kind, in order to lift the possibilities of retrieval of information to the highest limits. For example, since the database on products, risks and experts stores information linked to international classifications of products and risks (Tariff and Statistical Nomenclature, ICECI, ICD-10 and NEISS), it is feasible to create an interface with other databases and electronic systems (such as EHLASS, CSREID or EuroSafetyNet). This associative process would produce much more complete information in the field of consumer protection, and therefore, the potential for exploitation of results is very high.

The European Commission’s Fourth Framework Programme for research has supported the development of the Consumer Product Safety (CPS) Database so far. That Framework Programme was highly influenced by the RTD provisions introduced in the Treaty on European Union and by the Commission’s White Paper on Growth, Competitiveness and Employment. Now that the Fifth Framework Programme (FP5) has come into force, the adaptation of the project to the new themes introduced by the FP5 has been smooth and fast. Protecting the consumers, benefiting from the information society, putting research at the service of the citizen and concentrating efforts in specific areas to help to solve problems are
samples of those new themes in which the database fits completely. Adaptability is only a consequence of the rational application of technologies (not too much, not too little) to support the implementation of EU policies.

Following on the same line, the application of the latest information technologies to the database will facilitate immediate reactions to upcoming needs. The short time of reaction could contribute to the self-confidence of consumers and entities involved in consumer protection, which is necessary in an every day, more open world.

Identifying the coming needs is a task that must be undertaken by researchers and policy makers. The CPS database will serve the corresponding FP5 objectives, but in addition there are a number of possibilities that should be explored. For example, the CPS database could help to underpin harmonisation in the field of consumer safety for the new coming members of the Union. Furthermore, association and co-operation with other systems in the same field can bring to light unexpected possibilities that should be explored.
MODELLING PERCEPTIONS OF RISK FOR FOOD RELATED HAZARDS

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The concept of risk is socially constructed with public perceptions of risk being complex and different from those of expert risk assessors. The aims of the present studies were to understand 'Who Fears What and Why?' in the context of food related hazards. Exploratory work indicated that the main perceptual dimensions against which people define food related hazards varies within lifestyle-related and technology-related hazard domains. A questionnaire was developed and piloted to measure the factors driving perceptions of risk for a high fat diet, genetically engineered food, and BSE. The utility of structural equations in modelling the impact of highly related factors on perceptions of risk for these different types of hazard was demonstrated. Analysis of the pilot studies indicated that separate models should be derived and compared for perceptions of 'Personal Risk' and 'Risk to Others' for the different hazards. For the main survey, subjects were recruited primarily through the consumer panel of a private market research company. Mean risk ratings were found to be higher for a high fat diet than for BSE, which were higher than those for genetically engineered food, and an optimistic bias was found for all of the hazards. The impact of perceived characteristics, social context and individual differences on perceptions of 'Personal Risk' and 'Risk to Others' were modelled for each of these hazards. It was concluded that the factors defining perceptions of risk are very complex and hazard specific. The mechanisms underlying the observed optimistic bias effects also appeared to vary for the different hazards. Implications for theories of risk perception and risk communication strategies will be discussed.
ABSTRACT
To provide a context for disseminating the findings of the CESAR study (Central European Study on Air pollution and Respiratory Health), it was recognised that it would be advantageous to understand how environmental risks are perceived. There was very little information available on this in these countries, especially since their rapid transformation.

Objectives: The main objectives of the risk perception (RP) study were to develop a methodology to assess risk perception, public knowledge of environmental health information needs in the population, and to develop the skills of scientists and public institutions to communicate with the public on the results of research on environmental health.

Method: Several methods were employed. An RP question included in the parents’ questionnaires in the health study; semi-structured interviews with 6-7 key informants or “stake-holders” per area; some focus group discussions with parents of children and an RP questionnaire survey sent to a random sample of some 600 per area in the CESAR study. Perception of general, health and environmental problems and also responsibility for these problems and risk communication issues were addressed.

Results: Some results indicate differences between the six countries. They had some similarities in their shared communist past, but the evolution of perception and beliefs are not the same. The results of the RP study reflect the culturally and socially determined perception of risks. Within each area, the pollution status of the town, the socio-economic status of the family and the health of their children are all predictors of the relative importance accorded to different potential risks. The RP study has proved useful in assisting the development of local strategies for disseminating and discussing the research results.

1. INTRODUCTION
The CESAR Project was co-ordinated by the National Institute of Public Health and Environmental Protection in the Netherlands, the London School of Hygiene and Tropical Medicine in the United Kingdom and the Agricultural University Wageningen in the Netherlands. CESAR was carried out in several regions in Poland, Hungary, the Czech Republic, the Slovak Republic, Romania, and Bulgaria. In each country four sites with different levels of air pollution were selected. The CESAR study was focused on children aged 7-11 and the number of children was 4,000 per country, it means the total number 24,000 children, therefore the CESAR Project is one of the largest studies on air pollution and respiratory health in the world.

1.1. Projects formulated for the research programme
• A project on the relationship between ambient air pollution and chronic respiratory disease in children – health study /HIS/: consisted of exposure measurement, health questionnaire research, lung function testing, immunology study
• A project on quality assurance
• A project on risk perception /RP/ and risk communication
The RP and communication study was focused on following objectives: to provide descriptive data on the environmental risk perception of different stakeholders and different communities; to
determine beliefs and conceptions about risk, in general, and in particular how air pollution is viewed relative to other social and environmental issues, to understand the differences between the public and stakeholders view of responsibility for environmental risk management; to generate baseline descriptive data against which a future survey might be compared.

2. EXPERIMENTAL

The Risk Perception and Risk Communication study was divided into 3 (respectively 4) parts:
- a broad „environmental awareness“ questions included in health effects questionnaire /HQ/ distributed to the parents of the children in the health study /24,000 children in six countries involved/
- semi-structured interviews /SSIs/ with 154 „stakeholders“ (also called „key informants“) in study locations
- a structured risk perception questionnaire for population samples in each of the study locations /14,400 respondents involved/
- an additional study (provided in 3 countries) of focus group discussion /FGD/ with the group of teachers* (Bulgaria), the parents* (Czech Republic), 2 groups of the children* (Hungary) and the group of national NGO (Hungary)
  *children (their teachers, parents) involved in the health survey

2.1. Environmental awareness questions from HQ

In the main phase of the CESAR Project the health questionnaire was distributed to the parents of children. Except of questions concerning the health status of the child, living conditions, family history etc., also a broad “environmental awareness” questions were asked.

The analysis of these questions had two objectives - to establish what risk factors respondents perceive to be causes of respiratory health problems in children and to describe how perceptions of respiratory health risks may be related to: (i) area, (ii) health status of the child, (iii) socio-economic status, (iv) smoking habits.

2.2. Semi-structured interviews with stakeholders

For the semi-structured interviews 7 stakeholders (elected official, environmentalist, manager from a local large industrial plant, trade unionist from the same plant, NGO representative, physician, journalist) in each area were chosen and they were asked the core questions on certain topics and the answers were tape-recorded. The data obtained were analysed in categories according the topics: air quality, soil and water quality, health effects of air pollution (generally and locally), relative concern for environment compared to other concerns, influences on risk perception (openness of authorities, trust in responsible authorities, media publicity, controllability of exposures, citizens participation, disadvantages of expenditure on environmental control), usefulness of CESAR study, suggestions for communicating results.

2.3. Risk Perception Questionnaire

In reflection to the results of the SSIs and the FGDs the risk perception questionnaire was elaborated and sent to a random sample of adult population /600 per area/ in the CESAR study.

2.4. Focus Group Discussions

FGDs were the additional part of RP study, applied in 3 countries. There were provided the FGD with the group of teachers /7 participants/ in Bulgaria, with the group of parents of children in the Czech Republic /7 parents/, with the national NGO group and 2 groups of children /8 members
each/ in Hungary. Participants of FGDs were asked the same/similar questions as stakeholders in SSIs.

3. RESULT AND DISCUSSION

3.1. Risk perception Questions from the Health Questionnaire

The most frequently perceived causes of poor respiratory health in children were industrial pollution (71.7%), cigarette smoke (46.4%) and traffic fumes (44.9%). The last risk factor was not mentioned as the third in Romania, where the cold wet weather was mentioned more often. Respondents living in dirty areas were more likely to identify outdoor factors, especially man-made ones (industrial pollution was two times more likely to be identified), compared with respondents living in clean areas.

Parents of children with respiratory symptoms were more likely to identify natural outdoor factors than were parents of healthy children. Parents of children with a diagnosed respiratory disease were less likely to mention any of the man-made outdoor factors and more likely to mention high pollen count and cold wet weather as causes of respiratory problems. Parents of children with asthma were two times more likely to identify natural outdoor factors compared with parents of healthy children. Less educated group of respondents was more likely to identify cigarette smoke compared with respondents educated to a higher level but were less likely to identify personal and man-made outdoor factors. Manual workers were more likely to identify cigarette smoke (the prevalence of smoking was higher in this group) and natural outdoor factors compared with non-manual workers and less likely to mention personal and man-made outdoor factors. No difference was found between smokers and non-smokers who identified smoking as a risk factor, but non-smokers living with a smoker identified smoking as a risk factor more frequently.

3.2. Semi-Structured Interviews

The presented results are not homogenous and consistent within all countries areas and stakeholder-types. The presentation would like to give the insight how various risk problems are dominantly perceived by the most stakeholders in the involved countries. In general problems predominated the social problems such as unemployment, low quality of life, life expenses, economic crisis, crime, concern for future over the environmental problems in Romania, Bulgaria and Hungary – the RP reflect the economic situation of the country and the people much more than the real status of air pollution. The problems of everyday surviving and pessimistic fears of future are on the top in the general problems. The environment is according the stakeholders the issue which can come on schedule after the basic needs are satisfied. The perception is influenced by the statement (expressed by a stakeholder from Romania): The poor man is not taking care of his health but of his cow. In Bulgaria there people are prepared to be paid for health harm and obtain additional financial resources.
In other countries people are much more sensitive to environmental problems and their relation to people health. The importance of education was stressed in the most of countries. Slovakian stakeholders perceived that in people with lower education the health issue is given on the top, while the environmental one behind the social and economic issue. In the Czech Republic the life-style and stress were mentioned more risky factor than air pollution.

In environmental problems stakeholders mostly perceived the decreasing level of industrial pollution (in Romania caused mostly by stopping most polluted production more than taking measures), but emerging increase of traffic pollution caused by increasing number of cars used and also by use of old cars without catalyses. Within countries the perception of environmental problems is more sensitive in polluted areas than in clean ones. Attitudes towards ecological risks are controversial between lay people and experts and decision-makers – and are connected with controllability of risk (passivity of people) and the cost/benefit of the risk production (if the most polluted production would be closed, the impact to social problems, especially unemployment, will increase). In Poland there is generally thought that the costs of environmental pollution – human health – is very high, but the restoration of industry would lead to the unemployment and the re-qualification process should be organised parallel. The environmental legislation is mostly perceived to be sufficient, but enforcement of law is not enough.

In the rank of indoor air pollution issue lack of knowledge and low awareness was presented, if perceived – mostly the home dust, smoking and heating were mentioned as the sources. Among health problems mostly various allergies, respiratory diseases and asthma (especially in children) were given into relation with air pollution and were also perceived as dominated health problems. In Romania also occupational diseases were mentioned. As a new phenomena psychological problems were perceived – hopelessness in Bulgaria and Romania, and stress caused by working overload in the Czech Republic.

The responsibility for environmental and health problems was given mostly to institutions; lack of personal responsibility, often connected with the level of education and ecological culture, was perceived. The information is given in not proper way – too scientific or too detail. In most of the countries involved people do not trust the responsible institutions and media, in Bulgaria people even feel that the information could be used as the measure of political manipulation.

3.3. Risk Perception Questionnaire

The analysis of RP questionnaires has still been in the process. The only provisional results are available from the country specific analysis in the Czech Republic. The general problems of the most concern to respondents the local environment, quality of health care and crime were perceived. As for environmental problems the worsening trend of air pollution caused by traffic was mentioned (49.9%). Nearly 93% of respondents thought that the measures should be taken for the improvement of local air pollution. The responsibility for the changes was given only to institutions; the predominated obstacles were – lack of finance, bad law regulations. Comparing the outdoor and indoor air pollution 59.8% respondents perceived the outdoor air pollution being the cause of health problems. Only less part of respondents was informed on indoor risks. Trends of all health indicators were perceived as worsening, especially in allergies, asthma, cancers and respiratory diseases. Air pollution was indicated as the cause of worsening trend. The physicians and national press were perceived to be the most credible part of the society.
3.4. **Focus Group Discussions**

The teachers and parents FGDs resulted to the similar risk perception as the SSIs. Teachers stressed the necessity of new approaches to ecological and health education and also the importance of sport activity, especially for children. Parents expressed the feeling of helplessness after negotiations with institutions. Physicians were mentioned as the most credible source of information.

Very interesting insight to environmental problems offered the FGDs with children. Children were much more sensitive to the environmental problems and their perception has not been effected by economical problems. As the source of air pollution children evaluate mostly smoke, caused by factories, cars, cigarettes and pipes. Water pollution was caused by throwing a rubbish into lakes, let out the sewage of factories in surface water, which cause death of fish and frogs. Children mentioned a lot of causes of indoor-air pollution – dust in carpets, pillows, teddy bears, pets, insects, poison, sprays and cigarette smoke. Lot of children mentioned the allergic problems caused by smoking or by pollens. Most of information they received at home, from environmental films, books, TV programs. Children perceived that everybody is responsible for the environment, but some groups are more responsible – environmental protection institutions and politicians.

4. **CONCLUSIONS**

The risk perception in the former socialist countries differs from country to country. The environmental and health awareness depend not on the real present status of people health, environment, air pollution concentrations etc, but on other factors.

The predominated factor is **economical situation** – people with the very poor personal situation have another priorities, the problems of environment come on schedule after the basic needs are covered; **SES factors** – people with the lower SES have not enough information and in ordering of priorities give environmental problems lower that the ones with the higher SES, especially more educated; **trust in technological measures and responsible authorities** – people who trust the informants, technological measures and responsible authorities are more optimistic, have a feeling that they are a part of communication process and feel more controllability of risks; people are much more pessimistic if they do not trust the media and authorities; they do not trust in case that they have a feeling that the environmental information is the political tool of public manipulation. Very important is also the **way of information obtained** – the information should be given in a proper way, understandable, not too detailed and scientific, in a “what and how to do” format. The last can be listed behaviour differences – ecological culture, life-style.

In spite of that the risk perception is different in the 6 involved countries, there were some **common findings**, which are very important:

- need to focus on young generation – education in environmental/health issues
- educational approach will bring more sensitivity for environmental issues
- physicians are one part of society which have necessary data available and which is credible for common people
- more/less reduction of industrial pollution due to the technological appliances/measures and also stopping the most polluted production
- emerging increase of traffic pollution – old cars, trucks, buses without catalyses, lack of highway bypasses, insufficient public transportation
- health of children is very sensitive indicator to shake up public apathy
5. ACKNOWLEDGEMENTS
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6. REFERENCES


RISK PERCEPTION OF ENDOCRINE DISRUPTING CHEMICALS IN JAPAN

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ABSTRACT
In Japan, the media have repeatedly reported on the issue of endocrine disrupting chemicals for the last two years. One of the features of this problem is that public opinion, based on risk perception of the general public, plays a crucial role in regulatory decision-making. In this study, a postal survey was undertaken to assess the public's risk perception and behavior towards health risks of endocrine disrupting chemicals, and to investigate the role of public trust.

1. INTRODUCTION
In the last few years, potential health risks from exposure to endocrine disrupting chemicals (EDCs) have become an issue of significant public concern in Japan. Sensationalism has appeared in the mass media. However, due to the lack of scientific information regarding EDCs, policy designs were based on public concern, not on scientific risk assessment. This situation is common in many risk issues, such as bovine spongiform encephalopathy, genetically modified foods, and electromagnetic fields. However, the problem of EDCs is more complicated than other problems in that potential risk will be posed on the fetus and on future generations. This study is designed to examine the risk perception of EDCs in Japan.

2. METHODS
A postal survey was conducted in three cities of Ueno, Kashiwa, Tsukuba, all located in Kanto District in Japan (September and October 1998). Subjects were sampled randomly, with the condition that they had more than one child in the age group from 10 to 15 years, which was assumed to be an average Japanese family. The rate of return was about 35%. Five percent of all respondents were excluded from the following analysis because they did not recognize the term “EDCs”. The sample size was 517. Among them, 30% were female and 70% male. The average age was 44, from 29 to 57. The questionnaire consisted of 14 questions that covered knowledge and sources of information; risk perception and behavior; willingness - to - pay; trust; and personal information such as gender, income, age, academic background.

3. RESULTS
3.1 Sources of Information
The respondents heard the term “EDCs” on TV (83%) and read it in newspapers (95%). More than half of them first heard this term on TV (59%), and one - fourth, in newspapers (26%). The remaining consisted of magazines (9%), friends (3%) and books (2%). Since then, they were getting information mainly from TV, newspapers and magazines. Some respondents stated that the Internet was also an important source of information.
3.2 Risk Comparison
EDCs were of particular concern to 12% of the respondents; 62% of the respondents were moderately concerned; and 24% of respondents had little or no concern. Figure 1 shows the scores of perceptions of various risks to their children and descendants, including genetically modified foods (“GMF”), electromagnetic fields (“EMF”), global warming (“GW”), traffic accidents (“TA”), and environmental tobacco smoke (“ETS”). In each of the problems, we applied a 0 to 10 seriousness index scale, with 0 indicating a risk that was not considered serious and 10, very serious. EDCs had a relatively high score compared with other risks.

![Figure 1 Perception of various risks](image)

3.3 Perception and Behaviour
We categorized protective behaviours into five stages.
- Stage 1 Takes no measures and does not intend to gather information.
- Stage 2 Takes no measures, and has no interest in gathering information.
- Stage 3 Gathers information, but takes no measures.
- Stage 4 Takes protective measures, such as avoiding EDCs in shopping.
- Stage 5 Takes protective measures and conveys information to others.

It was observed that risk perception and respondents' behaviour had a significant association. That is, the more the respondent was concerned about EDCs, the greater the protective measures he or she took. Their stated perceptions were consistent with their behaviours. We also found that the more books they read, the greater the protective measures they took.

3.4 Endpoint
EDCs have many suspected effects which had been published by the mass media; increase in the number of reproductive effects on wildlife (“WIL”), decrease in sperm count (“SPE”), increase in cancer incidence (“CAN”), reduced female fertility (“FER”), increase in genetic defects (“GEN”), change of sex ratio (“RAT”), increase in the number of allergy cases (“ALL”), increase in learning disability (“LEA”), increase in homosexual population (“HOM”), disappearance of difference between sexes (“DIF”), increase in the number of children with volatile character (“CHI”), extinction of human species (“HUM”). In each of the endpoints, we applied a scale of 0 to 10, with 0 indicating a risk that would never occur and 10, that would definitely occur. The results are shown in figure 2.
3.5 Trust

Trust in risk information may be an important determinant of consumer perception and behaviour. The respondents most trusted university scientists ("UNIVE") to tell them the truth about EDCs and mainly trusted newspapers ("PAPER") and televisions ("TELEV"). However, administrative officers ("ADMIN") and industry ("INDUS") were not trusted. In each of the media, we applied a scale of 1 to 5, with 1 indicating a reliable source of risk information and 5, unreliable. The results are shown in figure 3.

Next, we examined the importance of trust as the determinant of risk perception and behaviour. The seriousness index of EDCs was positively associated with trust on university scientists (p<0.05) and negatively associated with trust on administrative officers (p<0.05). The stage of protective behaviour increased as the trust on university scientists increased (p<0.05) and decreased as the trust on administrative officers increased (p<0.001).
3.6 Value of Information
Respondents were asked regarding their willingness - to - pay (WTP) for the services of a licensed technician to analyze their daily exposure to EDCs and advise counter-measures. These answers were interpreted as the value of additional information. Average WTP was \$5,000, although 18% refused this service even if it was free of charge. The WTPs stated by the respondents were positively associated with the risk perception of EDCs (p<0.05), the number of books they bought (p<0.01), and their income (p<0.01). It was interesting to note that those who did not trust administrative officers as a source of information had a tendency to state a higher WTP.

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RISK COMMUNICATION ON RADIATION CONTAMINATED TERRITORIES

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1988-1998 years questioning study revealed unsatisfactory level of radiation-hygiene knowledge in various social population groups on radiation-contaminated territories. The same is correct for Chernobyl Accident liquidators.
Almost third part of population (30-40%) have the mythological radiation risk perception. This is like the psychological defence of the injustice or incomprehensible occurrence. It is the real situation absence the science proved radiation risk perception for all population, especially for those who have the low level of education. Only the higher medical qualification and medical doctor’s working experience at the contaminated territories regular resulting with the science proved radiation risk perception and it’s subjective adequate evaluation.
The Ministry of Health official documents concerning radiation risk communication - especially for radiation contaminated territories - were prepared in according with the population’s radiation risk perception.
EVALUATION OF THE INFORMATION INITIATIVES ADDRESSED TO THE POPULATION POTENTIALLY AFFECTED BY THE CONSEQUENCES OF A CHEMICAL ACCIDENT

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ABSTRACT
According to the Italian law, information on major chemical hazards must be addressed to the population that might be affected by the consequences of a chemical accident. In order to evaluate the impact on the target of the information initiative planned according to the law requirements, a survey was carried out in a municipality where a chemical accident can occur. Two samples of population were randomly selected in the same municipality: the first sample living in the area that could potentially affected by the risk consequences, and the other in an area which cannot be involved in an accidental event. A comparative analysis was then performed on the risk perception and information needs referred to industrial risks. Furthermore, in the sample living in the industrial area, the impact of the information provided for by law has been analysed. This in order to evaluate the consciousness of risk and acceptability of the information initiatives. With respect to the last statement, the analysis shows a significant high proportion of non-respondents, around 40% in both samples. More in general, the results show that the information model does not satisfy the safety needs of the population and reinforce the necessity to develop an information process flexible and participatory, suitable to the needs of local community.

INTRODUCTION
Italian law regarding the information of population on major industrial hazards came into force in 1997. According to the Seveso Directive, an active spreading of the information to the population liable to be affected by the consequences of a major hazard has been regulated. The information model, as indicated by law, requests the industry to provide technical information on risk existing in the plant. The emergency plan authority (Prefetto) must integrate the technical data with further information, regarding the procedures and the behaviours to adopt in case of emergency. The Mayor of the town provides to send all the information to the people living in the area involvable by the consequences of a major industrial accident. People “at risk” is defined by the emergency plan as the target population. Nevertheless, because of slow bureaucratic procedures regarding risk evaluation process and difficulties in co-ordinating initiatives among various authorities involved in the information process, the emergency plans are, in many industrial areas, still provisional or in progress. The aim of this study is to verify whether the adopted informative model can effectively increase the awareness of risk and induce correct behaviours during emergency, as regards risk message and the whole information process (2-3).

MATERIALS AND METHODS
The area under investigation is represented by an art city in the North of Italy, Mantova. Five chemical industries, considered by Italian law at risk of a major accident, are located in the outlying area. In accordance to the prescribed procedure, a target population was identified and informed by the Mayor of the town. 2000 families, living in the industrial area covered by a provisional emergency plan, received five information data sheets predisposed by the five
industries located in the area. In addition, the Mayor of the town provided a leaflet containing information useful for a deeper understanding of the technical contents of the risk message. In order to evaluate this initiative, a survey was performed. Two random samples of 150 citizens each, aged between 18 and 70, were selected from the register of residents. The first sample is representative of the target population, as defined by the provisional emergency plan. The second sample is representative of the population living in the city centre, out of the area at risk and not involved in the informative initiative carried out by the Mayor of the town. The survey was performed through a questionnaire administered by trained interviewers. The first part of the questionnaire was administered to both samples in order to perform a comparative analysis on the following items:

- perception of risk factors existing in industrial societies and, specifically, in their own residential territory;
- information needs about actual industrial risks;
- trust in the institutions competent for the informative initiatives;
- perception of risks and benefits due to the industrial activities existing in the area.

The second part of the questionnaire was administered only to the sample that received the informative material because living in the area potentially at risk. The main intent of this part of the survey was to evaluate:

- the awareness of the major industrial hazards in the exposed population
- the acceptability of the informative initiative performed in accordance with the law.

RESULTS

The first result is the very high proportion of non-respondents in both samples, 40% in the industrial area and 37% in the city centre. The proportion of non-respondents by sex and age show higher values for females (46%) and for younger subjects aged between 18 and 30 (53%) in the first sample, while in the sample of the city centre a higher value is registered among older subjects (50%). From a statistical point of view, the samples of the respondents do not well represent the population anymore; the number of subjects in each sample is too low for performing comparative analysis; and the internal validity could be compromised. However, we still consider important to discuss these results and analyse the reasons of this ‘failure’, as this experience offers some useful indications on the validity of the whole informative process adopted, beyond the statistical limits.

The performed information initiative must be analysed considering its methodological complexity, both in terms of procedures and in terms of content of the risk message. Non-respondents declare not to be interested in the proposed issues and, furthermore, they declare to distrust any initiative promoted by public institutions. This is an unexpected reaction considering that it comes from a population living in an area where many industrial activities are located.

Some results, regarding only the sample referred to the industrial area, confirm this attitude towards the treated issues. For example, though everybody should have received the informative material, only 50 subjects (60%) declare to remember it. Some of the subjects could have not really received the informative material, because the population potentially at risk is not well defined by the emergency plan. However, it seems that, because of the low publicity given at the initiative by the mayor of the town, the subjects did not consider the received material with the proper attention. Moreover, the proportions of those who consider their knowledge very improved or partially improved because of the informative material received, are 56.5% and 65.3% respectively for the technical information sheets and for the leaflet. At the same time, the leaflet was considered by 73.5% of the subjects an information tool useful to increase the comprehension of the risk issues provided in the technical sheets.
Besides, the hypothesis that the proximity to the plants can influence different reactions in the two samples was not confirmed. In fact, no differences came out from the descriptive comparison between the results referred to the two samples with respect to the following issues: risk perception, information needs, trust towards institutions and perception of risks and benefits due to industrial activities. Results in Fig. 1 show the severity of risks existing at the local level as perceived by the subjects. The perception of the risk of a major chemical accident is very low in both samples, about 30%. On the contrary, the perception of industrial and urban pollution is very high. They are widespread and well-known risk factors, commonly covered by mass media. As we said before, there are no differences in perception of the samples and this result indicates that living near an industrial area "where a chemical accident can occur" does not increase the anxiety towards the industrial risks. The citizens of Mantova seem to show homogeneous attitudes and behaviours towards risks typical of urban communities.

![Graph](image)

**Fig. 1** – *Hazards and severity degree of risk at local level as perceived by the subjects (1 = industrial area; 2 = city centre)*

Regarding the contents of risk message, Fig. 2 shows the behaviours adopted in case of a chemical accident by the sample of the industrial area. The results show some contradictions between correct and wrong behaviours. More than 85% of the subjects declare to close doors and windows in case of emergency, but at the same time, about 70% would go and meet their relatives or would go to pick up children from school. This could indicate that citizens distrust the capacity of the school in guaranteeing children safety. Moreover, this result shows that the given informative message is inadequate and it cannot fulfil the safety need of citizens.
CONCLUSIONS

Some limits affecting the present study were produced by the inadequacy of the risk management including risk communication process at the local level. They refer to difficulties in choosing the target population due to the present absence of a definitive emergency plan; poor co-ordination among the institutions managing safety and information process regarding risk; poor publicity given by public authorities to the information initiative on major hazards. On the other hand, more in general, survey results confirm an historical absence of initiatives aimed at promoting communication and public participation regarding risks affecting the community. Besides, the evaluation of the effectiveness of the present information initiative show that the proposed objectives have not been reached both in terms of consciousness of risk and knowledge of behaviours to adopt in order to mitigate damage. Furthermore, the present informative initiative did not increase the citizens trust in the authorities responsible for the management of major accident hazards, as the motivations given by the non-respondents pointed out and the results of the survey confirmed. On the contrary, the citizens show a high trust level in the health, environmental and safety technicians, that are considered familiar and easily identifiable as professionals able to satisfy the citizens need of safety (1).

Further considerations can be focused on the contents of the risk message, as prescribed by Italian law. Because of the treated matter, uncertain and catastrophic risks, and because of the adopted language, extremely technical, the information material provided by the industries seems to be inadequate to increase the awareness of citizens on the risk of a major chemical accident. On the whole, the prescribed information model seems to be too strict and unable to fit the needs of the target population, which is not homogeneous in terms of perception and education. Moreover, it neglects relevant elements necessary in pursuing the success of the informative initiatives on risk as, for example, trust in those responsible for risk information and management, and participation of the community in the decision making process regarding major chemical hazards. A greater effort is required to public authorities in order to co-ordinate all the resources involved in the risk management and to promote a local,
continuous, flexible communication process. Such a process should include procedures able to verify the real correspondence between the results achieved and the initial objectives. The information process should also guarantee the conditions necessary to be able to verify its effectiveness at different phases.

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BIBLIOGRAPHY
DETERMINANTS OF RISK PERCEPTION: UNIVERSAL OR HAZARD-SPECIFIC?

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ABSTRACT

The goal of our study was to clarify the determinants underlying people’s subjective appraisal of the riskiness of environmental problems for human beings. It is assumed that risk judgements with respect to environmental risks are a function of their ratings on the relevant psychological risk dimensions. In a psychometric study, 461 subjects with different professional background (natural sciences, engineering, economics, social sciences) evaluated 30 environmental problems on 13 judgement scales. The regression analysis shows that the essential predictors of the risk judgements are the perceived frequency of harm, the perceived amount of harm and the emotions evoked by thinking about the threats arising from environmental problems. The results of ANOVA show that the subjective judgement of both the perceived frequency and amount of harm vary according to the risk source. By contrast, the various emotions evoked by the different risk sources are explained above all by interindividual differences. The regression model does not satisfactorily predict the risk judgements for one class of environmental risks, namely the conditions of and changes in the biosphere. This finding points to the conclusion that more specific evaluation criteria are involved in the evaluation of this class of risks.

INTRODUCTION

Psychometric risk research has shown that for laypersons the assessment of the magnitude of a risk depends on a number of subjective evaluation dimensions. Psychometric risk research has to date paid little attention to the issue of the subjective assessment of risks for people from the environment. Major attention in psychometric risk research has been centred on technology, product and health risks. The only studies to include a number of anthropogenically initiated environmental problems in the item pool centered the characterization of the perception of these risks for the environment. (1,2) Brun’s study (3) dealt with the comparison between anthropogenically initiated environmental problems and natural environmental risks. Little is known about the determinants which explain the subjective assessment of risks resulting for people from environmental problems and whether this model of risk judgement is hazard-specific or holds for environmental risks in general.

METHOD

The subjects were 461 advanced students and university staff. The sample included subjects from three types of academic disciplines. The first group (N = 186) were students of the social sciences. The second group (N = 222) were subjects with a professional background in engineering or the natural sciences. The third group (N = 53) were students of economics. The subjects had to judge 30 environmental risks with regard to 13 risk dimensions. The list of environmental risks comprised all the media of soil, water, air and biosphere. The selection of judgement aspects was primarily oriented to McDaniels’ study(1) on the assumption that the aspects relevant for assessing risks for the environment are also relevant for assessing risks from the environment. Various studies point to the fact that in particular the probability of an
event is a significant psychological evaluation dimension. The aspect of uncertainty was therefore operationalized on the basis of three different rating scales, namely "frequency of harm", "probability of harm" and "forecast of negative impacts". Unlike most previous studies, the connotative aspect is not operationalized as fear or dread, but by asking for the extend of "negative feelings" associated with thoughts of ecological risks. The judgement of the overall risk possibly associated with various environmental problems for man functions as a dependent variable. Ratings for the evaluative aspects were given on 7-point Likert-type rating scales with verbal end points.

RESULTS

According to the psychometric paradigm, with respect to different risk sources risk judgements are "a linear function of its value on the psychological risk dimensions". Data analysis was performed by multiple regression analysis. A data matrix with 186 (persons) X 30 (risk sources) rows and 13 (judgement dimensions) columns was used as raw data. Thirty virtual new persons were generated from each person, i.e. the judgements on each of the 30 environmental problems were treated as independent cases. The results show that the strongest predictor is frequency of harm. It displays the highest data weight. The two next most important predictors are amount of harm and emotionality (see Tab. I).

Tab. I: Summary of the hierarchical regression analysis for predicting the criterion variable of "risk"

<table>
<thead>
<tr>
<th>Source of knowledge</th>
<th>β</th>
<th>t</th>
<th>p</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novelty</td>
<td>-0.10</td>
<td>-10.52</td>
<td>&lt;0.01</td>
<td>1.53</td>
</tr>
<tr>
<td>Frequency of harm</td>
<td>0.32</td>
<td>25.80</td>
<td>&lt;0.01</td>
<td>2.72</td>
</tr>
<tr>
<td>Duration</td>
<td>0.02</td>
<td>2.75</td>
<td>0.01</td>
<td>1.40</td>
</tr>
<tr>
<td>Amount of harm</td>
<td>0.18</td>
<td>13.94</td>
<td>&lt;0.01</td>
<td>2.89</td>
</tr>
<tr>
<td>Personally affected</td>
<td>0.12</td>
<td>9.89</td>
<td>&lt;0.01</td>
<td>2.74</td>
</tr>
<tr>
<td>Controllability</td>
<td>0.01</td>
<td>1.46</td>
<td>0.14</td>
<td>1.23</td>
</tr>
<tr>
<td>Emotionality</td>
<td>0.16</td>
<td>16.48</td>
<td>&lt;0.01</td>
<td>1.71</td>
</tr>
</tbody>
</table>

R² = 0.68

In order to identify the environmental problems for which the regression model is more or less well adapted, indicator variables for "environmental problems" were included in the hierarchical regression analysis. Dummy coding (0, 1) was used to generate the 30 indicator variables. The rating dimensions were entered in one hierarchical regression analysis as the first block and the indicator variables as the second block. The results show that for 16 risk sources the indicator variable "environmental problem" is a significant predictor for the criterion variable "risk". These risk sources have in common the fact that they involve examples from the biosphere sector, i.e. the extinction of whales and storks. The negative t values indicate that with respect to these environmental risks the risk judgement is lower than predicted by the predictors.

DISCUSSION

This study supports the results of other studies with respect to the significance of probability of harm for subjective risk judgement. The fact that the affective evaluation of risk is one of
the best predictors of risk judgement is also consistent with the results on technological and health risks. The feelings initiated by thoughts of such riskiness are of major significance. For further studies, it would be helpful to analyse those aspects which characterize the judgement dimension "feelings". Does this, for example, involve moral aspects, such as outrage, is it sorrow, disappointment or helplessness? An interesting finding is the fact that the perceived personal control does not influence the risk judgement. In numerous psychometric studies on technological risks, controllability proved to be a relevant aspect. (9) The smaller the perceived controllability of technologies by one's own person or by third parties was estimated to be, the higher were the risk judgements. This does not apply to environmental risks.

The environmental risks explained less satisfactorily by the regression model are those risks resulting from changes to the biosphere. This involves environmental risks which do not have immediately negative impacts on man, such as water or air pollution, but may only represent potentially negative consequences for man indirectly via changes to the ecosystem. These stimuli seem to have a different quality than those risk sources with direct impacts on man. The criterion variable "risk" was operationalized as "riskiness for human beings". Apparently the cause-and-effect chain in which the extinction of storks or the destruction of wetlands could also have negative impacts for human beings is not evident.

REFERENCES
RADIATION RISK PERCEPTION BY THE SPECIALISTS, WORKING IN ATOMIC ENERGY AND RADIOACTIVE WASTE MANAGEMENT

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The main purpose of the study was to investigate some aspects of subjective radiation risk perception and assessment by specialists, working at atomic energy and radioactive waste management in different regions of Russia. The questionnaire include 5 parts concerning: information about respondents; subjective risk evaluation of different danger for health (rating in a five-point scale) and danger in common (rank by risk ordering) factors; assessment of legislative and economic ways of ecological problems solving; radiation knowledge and it’s verification; evaluation of the trust to various sources of ecological information; determination of own behavior in connection with environment contamination and open question about respondents opinion on aspects of the radiation problem.

The 54 questioned specialists assessed most highly the danger for health of socially determinate factors: violent crimes, poor medical care, lawlessness and economic difficulties. The ecological risk factors were on the next places after cites above. The irradiation impact occupied 11-th place among 18 assessed factors. Rating of danger of various risk factors have resembled those ratings which were obtained in our previous work in the population on the territories, noncontaminated after Chernobyl Accident.

20% of professionals estimated their radiation ecological and hygienic knowledge like low by themselves. This confirms to objective evaluation of their knowledge. As a population in general “professionals” have not trusted to media, representatives of authorities. The majority of responses to open question were concerned with the necessity of information cover of radio-ecological and radiation safety problems.

So this results showed real need exists of increase of level of radiation hygiene and radio-ecological knowledge not only for all the population but also for specialists of atomic energy and radioactive waste management.
TRACK 3

SESSION 3

SOCIAL AMPLIFICATION - MEDIA
SESSION 3

RISK PERCEPTION BY THE SPECIALISTS, WORKING IN ATOMIC ENERGY AND RADIOACTIVE WASTE MANAGEMENT

Oleksandra V. Archanypetskaia, Elena A. Tylove

**Doctor of medical sciences, chief of the scientific group, Social and Psychological Consequences after Chernobyl Accident. 50% of Reducing Hypotheses

The main purpose of the study was to determine the severity of subjective radiation risk perception and assessment by specialists working in atomic energy and radioactive waste management in different regions of Russia. The questionnaire included 3 parts: assessing information about radioactive situations, subjective risk evaluation of different dangers, and surveying the social and economic state of the nuclear power plants. The knowledge and attitude of specialists about radioactive situations were compared with the results of the national survey.

The 54 questioned specialists were divided into three groups: specialists working in different regions of Russia, with varying experience and professional difficulties. The ecological risk factors were assessed using the same data. The results showed that the specialists from different regions have different levels of knowledge, experience, and professional difficulties. This information is important for improving radiation safety policies.

The specialists who have worked in atomic energy have a higher level of knowledge and experience. The majority of specialists are aware of the importance of radiation safety, but only a small number of them have specific knowledge about radiation safety policies. The specialists working in different regions of Russia have different levels of knowledge and experience, which affects their perception of radiation risk.

So, this study showed that the perception of radiation risk varies depending on the region and the level of experience of the specialists. The importance of radiation safety policies and the need for training and education are emphasized.
MAKING SENSE OF CHERNOBYL NINE YEARS AFTER:
TV News Reception Study of the Environmental Disaster

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ABSTRACT
The main objective of this qualitative reception study has been to explain the meaning making process of the authentic Chernobyl television news for fifteen key-informants who were involved in this disaster in Norway, nine years after the accident. The respondents were recruited from three categories: 1) Authorities and experts, 2) Representatives of the media, 3) Laypeople who were especially vulnerable during the disaster. The aim was to discover how the news affected their interpretations of the disaster and what kinds of thoughts, reactions and associations the risk messages provoked in retrospect, in the present and in the respondents' beliefs about the future. The ontological analysis was based on the application of Heidegger's existentiales and the epistemological analysis of Habermas' theory of the communicative action.

The findings indicate that the Chernobyl news on TV was mainly based on technical rationality, while the respondents more often constructed the meaning on the basis of symbolic, cultural rationality. A conflict between the transmitted risk messages, which the sender constructed in the physical time dimension, and the messages that were received in the anthropological time dimension was also found. In the previous Chernobyl studies inquiries have focused on the immediate fear response and on instrumental, technical risk perception. This study claims that the fundamental anxiety and the cultural context of risk experience have been overlooked in these studies. This doctoral dissertation suggests also that the transmitting of Chernobyl news led to a remarkable loss of credibility for the sender, and on the receiver end, the situation caused a great mistrust of the authorities, experts and even the media. The loss of credibility and trust are also the dominant features in retrospect.

INTRODUCTION
Environmental catastrophes, technical disasters and nuclear power plant explosions are a part of our everyday life through the television news. Strangely enough, there are very few studies that shed light on recipients' constructs of meaning of disaster news from a cross-cultural perspective. The study of audiences has traditionally been based on examining the behavioural effects of exposure to risk messages in the mass media, and the 'effects' of the messages are primarily measured through questionnaires. The studies on radioactive accidents have mainly been carried out from the sender's perspective. The content of the message in these studies has been understood as 'information', the manifest meaning of the text. Today these transmission models are regarded as insufficient. The media are seen as an integral part of a cultural process through which meanings are produced, and the messages are complex discourses with meanings encoded through culturally specific communicative codes. The ways in which individuals construct the meaning of news are functions of the particular context within which they live (Jensen 1990, Vettenranta 1998).
Television news is open to many different interpretations. More than information is conveyed through TV news, but these metamessages are not visible to the viewer. The real significance of news cannot be discovered on the empirically manifest level because this is latent and must be revealed through interpretative analysis. TV news plays a central role in the production and maintenance of meaning, and it is more important to treat the news as a form of cultural discourse than information (Dahlgren 1998, Jensen 1990, McQuail & Windahl 1993).

OUTLINE OF THE STUDY
The main objective of this study has been to explain the meaning making process of the authentic Chernobyl news on television for fifteen key-informants, seven women and eight men, who were directly or indirectly involved in this disaster in Norway in 1986. The informants represented three categories of involvement in the disaster: the authorities/the experts, the media and laypeople, recruited from groups, which were especially vulnerable during the Chernobyl disaster. The aim was to discover how the news affects their interpretations of the disaster and what kinds of thoughts, reactions and associations the risk messages provoke in retrospect, in the present and in the respondents' beliefs about the future. Furthermore, the goal was to contribute to an improved insight into the communicative limitations and possibilities of television as a medium regarding disaster news. Moreover, the study aimed at developing theoretical concepts in the field of risk communication.

A qualitative reception study was carried out in order to gain new knowledge about interpretation of risk communication on TV news from the recipients' points of view. Fourteen authentic newscasts about the Chernobyl disaster from the main Norwegian evening news were chosen. An extract consisting of a 40-minute videotape was shown to the respondents. The reception process was after showing studied through an in-depth interview, based on a semi-structured interview guide, and supplemented by observation. The interviews will be recorded in their entirety, transcribed as texts and analysed by the audience research approach, called 'reception analysis' (cf. McQuail & Windahl 1993). Its systematic and comprehensive, but not rigid character inspired the methodological choice of qualitative analysis. The possibility of understanding latent, underlying and nonobvious outcomes is good. Also the richness and holism of qualitative data help to reveal complexity (Huberman and Miles 1994).

This study was based upon a social constructivist research framework (cf. Burr 1995). From the constructivist viewpoint, thinking that the purpose of television news is to mediate the true picture about reality would be almost meaningless. In communication science, one talks about shared systems of meaning and not about truth. In this study, which adopts a hermeneutic-phenomenological basis, the primary interest is the human experience, the respondents' meanings and their subjective lifeworld. The respondents do not obtain direct information about reality, rather they experience the world, and through experiences they create new constructions of meaning. These constructions are the main interest of this study, stimulated by the TV newscasts about the Chernobyl disaster. This approach disputes the traditional, 'realistic' view of a language as a neutral tool reflecting social reality and questions the basic rules of traditional information production (cf. Potter & Wetherell 1987).

RESULTS AND DISCUSSION
Heidegger (1993) and his existentiales - such as anxiety, death and authenticity made the application of his ideas relevant in a study of a radioactive disaster. Heidegger seemed to fit well with the ontological analysis, in the epistemological analysis Habermas' (1984, 1987)
theory of communicative action appeared to be more adequate. Time is the foundation of being for Heidegger (1992); and it is the interplay between previous nuclear accidents and anticipated nuclear accidents in future in relation to the present situation that constitutes the concept of time. This anthropological time is primal to the physical concept of time. The information crisis during the Chernobyl disaster might have emanated due to a conflict between the transmitted risk messages, which the sender constructed in the physical time dimension, and the messages, which were received in the anthropological time dimension. Television news is conveyed as present images, while the viewers construct the meaning in a longer perspective, related to their past crisis experiences and anticipations of future risks.

The leading authorities represented the system world that was based on a technical and instrumental conception of rationality. The findings indicate also that the Chernobyl news on TV was mainly based on technical rationality, while only few viewers constructed the meaning from that perspective. The respondents more often constructed the meaning on the basis of symbolic, cultural rationality or value rationality. This alternative way of thinking had an ethical dimension: co-operation, mutual responsibilities and taking care of others. The information crises might have been intensified by the conflicting representations of senders' and receivers' rationalities. The transmission of catastrophe news is not just a matter of responding to the information needs of the public. Denotative risk messages simultaneously convey connotative, symbolic resonance of risk on a metaphysical level (Vettenranta 1996). The Chernobyl disaster had a powerful symbolic meaning for the respondents in this study, as 'synonymous with Hiroshima and Nagasaki', 'a symbol for ecological breakdown, political failure and treason' (Vettenranta 1998). The undertones of metaphysical thoughts connected to radioactivity indicate that the disaster news conveys symbolic resonance (cf. Corner et al. 1990). The symbolic dimension is almost totally neglected in risk communication research.

Previous Chernobyl studies have focused on the immediate fear response and on instrumental, technical risk perception of news. Heidegger (1993) distinguishes between fear and anxiety. Fear has a concrete object: cancer, gene mutations, and nuclear power plant explosion, while anxiety is not anxiety about any particular thing. 'Angst' is anxiety about death. In fear one is afraid of 'life', in anxiety one is afraid of 'death' (Heidegger 1993, see also Naess 1969 and Wind 1974). In my opinion, in the previous Chernobyl studies the fundamental anxiety level and the cultural context of risk experience have been overlooked. The inquiries have focused on the immediate fear response and on instrumental, technical risk perception. However, the reception and interpretations of risk news are polysemic, based on respondents' previous crises experiences and their anticipations of future hazards. From this stance, the view that the public is a uniform target group for risk messages in the disaster news is both incorrect and unworkable. This rigid target group approach is a heritage from quantitative studies, but it does not fit well in the risk communication design.

FROM HEIDEGGER TO HABERMAS
The point of departure for the epistemological analysis was Habermas' (1987) notion of communicative action. The basic idea that communicative action is based on mutuality and intersubjective understanding was correct in this material. Especially the demands for agreement between actors, and that the message should be open to negotiation and justifications were important. These were the preconditions of the respondents that they took for granted in a democratic information society. When these preconditions were not met, the presupposed agreement was broken and the condition for openness did not function, the situation led to a serious communication crisis. This led to an extensive loss of credibility for
the sender, especially the two main actors, the Directorate of Health and the National Institute of Radiation Protection in Norway. On the receiver end, the situation caused remarkable mistrust of the authorities, experts and even the media. The loss of credibility and trust are the dominating features also in retrospect. Important demands in Habermas' (ibid.) communicative action: The claims of correctness in the factual evidence, moral decency in relation to socially relevant norms and the authentic representation of the subject - all failed. When this happened in a lack of openness, in the shadow of hidden agendas, communication breakdown was a fact.

The most serious conflict in Norway occurred between the Directorate of Health and the Geological Survey of Norway, a struggle where the National Institute of Radiation Hygiene also became involved. The parties accused each other of deceit and dishonesty. The institutions are still suffering from this dispute. Furthermore, this serious conflict resulted in loss of trust among my respondents. They described the authorities' withholding of vital information as deceitful and treasonous. The authorities did not share the common stock of risk knowledge equally between the members in society, even though this was understood to be their right and obligation as citizens. The withholding of relevant knowledge from those who feel they are entitled to share it causes harm and damage to reciprocal relations.

Important demands for disaster communication are honesty, consistency, openness and mutuality. These demands were not fulfilled.

The television news transmission on the Chernobyl disaster is an excellent example of a failure in communicative action. The respondents could point to the characteristics that led to the communication crisis. Among the major failures were factors such as ambiguousness (different becquerel levels, divergent information from the responsible authorities) and plans to manipulate information (to use sievert instead of becquerel so that the values would seem less dangerous). Respondents also impeached the authorities of falsehood and anticipated lies (especially the representations of two leading directors), misinformation (from the Directorate of Health) and, attempts to arrest information (the Minister of the Environment).

CONCLUSION
Generally, the basis in risk communication research regarding the reception of the disaster news has not been broad enough. To shed light on the receivers' construct of meaning from the disaster news we need interdisciplinary approaches. So far, sociologists and psychologists have dominated the field. My study (Vettenranta 1998) indicates that scientists need methodological pluralism with backgrounds in social anthropology, philosophy and religious studies. These disciplines are needed to shed light on the cultural, metaphysical, ethical and temporal questions that emerge in the meaning-making process of disaster news. Unfortunately, there has been little interaction between cultural and psychometric traditions of risk research in the social sciences (Pidgeon et al. 1992).

ACKNOWLEDGEMENT
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MEDIA RISKS: THE SOCIAL AMPLIFICATION OF RISK AND THE MEDIA VIOLENCE DEBATE

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ABSTRACT
This article examines the conceptual framework of the social amplification of risk in relation to the social sciences framework of moral panic and the media violence debate in Britain. The paper will explore the symbolic use of 'risk' in relation to the alleged negative effects of media violence, and analyse the key stages in the social amplification of the physical and moral risks of media violence. Specific risk events in Britain, such as the death of James Bulger in 1993, or the Dunblane massacre in 1996, have particular event characteristics which inform the flow of information about the alleged risks of media violence, and influence political legislation and censorship. Analysis of the social amplification of the risks of media violence provides evidence of the ways in which the media, politicians and anti-violence campaign groups become social amplification stations. These organisations manipulate risk events to control information flows about stigmatised examples of popular culture and media audiences, with the aim to create a 'safer' moral and cultural environment.

INTRODUCTION
The issue of media violence is one that has received much media publicity. Particular examples of media violence, ranging from children's cartoons, to adult horror movies have been criticised by the public, the media, academics, citizen's groups and politicians for the alleged negative 'effects' of media violence to individuals and to society as a whole (Barker, 1984; Buckingham and Allerton, 1996; Barker and Petley, 1997). These alleged negative effects operate on physical and moral levels. The physical effects of media violence, such as copycat violence, have been well documented by academics in the field of social sciences (see Van Evra, 1990; Cumberbatch and Howitt, 1989; Gauntlett, 1995; Buckingham and Allerton, 1996 amongst others), but the moral effects of media violence have received little serious attention. It is my intention to examine the connections between the physical and moral 'risks' of media violence. The interpretive strategies used by professional groups, direct action groups, and religious campaign groups to campaign against media violence is shaped by the discourse of environmental hazards (Gamson and Modigliani, 1989; Eder, 1996; Wynne, 1992a, 1992b; Thompson, 1992). The application of the discourse of environmentalism to the media violence debate is best understood by using the conceptual framework of the social amplification of risk (Kasperson et al, 1988; Kasperon, 1992; Kasperon and Kasperon, 1996). The aim of this article is to examine the flow of communication after a media violence controversy, and consider how the model of the social amplification of risk can illuminate the way in which particular individual and social amplification stations amplify the alleged physical and moral risks of media violence. This research contributes to a wider
understanding of social theories of risk by illuminating the application of the masterframe of environmental discourse to a non-risk arena.

The evidence used to support this argument will be taken from recent media violence controversies which have been interpreted as ‘risk events’. For example, the death of two year old James Bulger by two ten year old boys in Liverpool in 1993 (Buckingham, 1996; Barker, 1997) sparked a ‘moral panic’ (Cohen, 1972; Cohen and Young, 1973) about the risks of media violence, as it was suggested by the popular press, professional groups, political and religious organisations that the two boys had been influenced by the horror movie Child’s Play 3 (Jack Bender, US, 1992). The James Bulger case prompted widespread public and official concern, and generated substantial political and social activism in Britain. Individual and social amplification stations, such as politicians and anti-violence campaign groups, used the James Bulger case to create an interpretive package which amplified the physical and moral risks of media violence (Gamson and Modigliani, 1989). Alarmist pronouncements were made concerning the alleged negative ‘effects’ of media violence, the corruption of children and increased levels of violence in society. One major impact of this risk event was that changes were made to the Criminal Justice Act (1994) in order to increase censorship and regulation of video use in the home (Barker, 1997).

Analysis of the social amplification of the physical and moral ‘risks’ of media violence will reveal how the main individual and social amplification agents in this debate mis-use the symbol of risk in order to manipulate channels of communication concerning media violence. Thus, my argument draws upon suggestions made by Ripp (1988: 195), in his review of the social amplification of risk framework, that researchers consider the way ‘hazard signals’ can be adopted and transformed by social groups. As media violence is commonly perceived as a ‘stigmatised’ form of popular culture by social commentators (see Barker and Petley, 1997; Kasperson and Kasperson, 1996: 99), horror, crime and action movies in particular receive much criticism for their alleged physical risks. However, this criticism becomes all the more powerful and dramatic if it is associated with the moralisation of risk (McNaughton and Urry, 1995; Eder, 1996; Renn, 1992). It is my intention to show how the moral risks of media violence provide professional groups and direct action groups with a rhetorical framework within which to argue for a ‘safer’ moral environment (Szerszynski, 1993; Hill, 1997, 1999).

Table 1: Overview of Four Case Studies of Social Amplification of Risks of Media Violence (adapted from Kasperson, 1992: 171)

<table>
<thead>
<tr>
<th>Risk Event</th>
<th>Media Violence Controversy</th>
<th>Information Flow</th>
<th>Social Group Mobilization</th>
<th>Socio/economic and Cultural Impacts (Rippling Effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Video Nasties’ (1983-4)</td>
<td>Specific horror films are found obscene by Director of Public Prosecutions</td>
<td>Local and national media coverage, highly dramatised, alarmist, popular press campaign to ban films</td>
<td>Widespread public concern, campaigns by citizen’s groups, NGOs, substantial political activism, conforming to pre-existing pattern in media violence debate</td>
<td>Parliamentary Group Video Enquiry in effects of media violence, list of horror movies banned from distribution, widespread stigmatisation of consumers of media violence. Video Recordings Act is passed, gives statutory footing to video censorship in Britain, and penalties to video supply outlets who supply age restricted videos to those under age</td>
</tr>
<tr>
<td>James Bulger Case 1993</td>
<td>Two year old boy murdered by two ten year</td>
<td>Local and national media coverage, highly dramatised, alarmist,</td>
<td>Widespread public concern, campaigns by citizen’s groups, NGOs,</td>
<td>Child’s Play 3 temporarily withdrawn from distribution, other films also</td>
</tr>
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OPENNESS ALLEVIATES FEAR
(MAJOR HAZARD COMMUNICATION IN THE NETHERLANDS)

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ABSTRACT
Communication about major hazards with the public in Europe is shaped by directive 82/501/EC
(the so-called Post Seveso Directive) and its subsequent revisions. In The Netherlands,
communication about major hazards has been made a local responsibility. Every 5 years an
extensive campaign must be held. In in-between years the most basic information must be
(minimally) distributed.
Approximately 20 cities in the Rijnmond area co-operate in extra large campaigns. This is not
surprising, because of the presence of the Rotterdam harbour with the largest petro-chemical
complex in Europe and more than half of all Post Seveso companies in The Netherlands. In
Rijnmond, as in all other campaigns, the rules of behaviour in emergency situations are
emphasised. In addition, a map is shown with information on specific risk sources in Rijnmond.
During preparation of the first large campaign in 1993, some municipalities objected against the
inclusion of information on risk sources and other ‘alarming’ and ‘critical’ information. They
were afraid it would frighten people or that the image of companies would be damaged.
The campaigns in Rijnmond led to a large increase in knowledge of the rules of behaviour. At
the same time, people became more aware of the possibility of disaster and more critical about
the mitigating possibilities of rescue services. However, their tendency to perform
counterprotective actions, like fleeing, decreased. Also, they were less afraid after the campaign.
The most likely explanation for the willingness to follow authority advice and the decreased fear
is that people found responsible authorities more open after the campaign. From the risk
perception and stress literature it is known that openness and predictability can decrease fear and
stress.
The beneficial effect of openness in communicating about major hazards has become a major
argument for openness in all risk communication practice in Rijnmond.

INTRODUCTION
Article 8 of Directive 82/501/EEC (the so-called Seveso Directive), its amendment in Directive
88/610/EEC and the revision in Directive 96/82/EC have stimulated and shaped communication
about major accident hazards in Europe. In an EC conference on ‘Communicating with the Public
about Major Accident Hazards’, Otway (1990) addresses several issues that should be better
investigated (see also Otway and Wynne 1989). One of the most important issues Otway
mentioned is the possible opposition between reassurance and readiness. Otway observes that in
risk communication about major hazards the balance has always been towards reassurance.
Many articles have been written to show that technologies or facilities objected to by the public
are acceptable. Somewhat ironically he remarks that no articles have been written about how to
convince people that a certain industrial risk is unacceptable. The emphasis on reassurance is in
sharp contrast to the need to alarm people to prepare for major accidents. Clear, vivid and
catastrophic images of disaster are most useful to alert people and to draw their attention to
emergency precautions.
The present article contains examples and arguments which show that in most instances open and
complete dissemination of information on major accident hazards does not increase, but alleviate
public fears. Examples are first shown for the dissemination of information to prepare people for
incidents. Next, examples of information dissemination during incidents are described. Finally,
some conclusions are drawn.

INFORMATION TO PREPARE PEOPLE FOR AN INCIDENT
Seveso Directive has been implemented in several laws in The Netherlands. Article 8 on
communication has been integrated as article 2 into the Dutch 'disaster law'. The article refers to
the 'Royal Decree concerning information in disasters' which prescribes the content, frequency
and procedures of information to the general public. A distinction is made between information
related to all types of disasters and information related to facilities falling under the Seveso
Directive. Information related to all types of disasters has to be actively disseminated yearly. Of
central importance in this information are the rules on behaviour in emergency situations.
Especially to this purpose, the so-called 'base scenario' has been developed. the base scenario
reads: "When the sirens go off ... (1) Go indoors immediately, (2) Close all windows and doors
and (3) Listen to the radio or television. Active communication concerning Seveso facilities and
other specific local risks must be done every 5 years.

The first Dutch campaign to prepare people for an incident was held in Rotterdam and some
neighbouring cities in 1990. This is not surprising, because of the presence of the Rotterdam
harbour with the largest petro-chemical complex in Europe and more than half of all Seveso
companies in The Netherlands. The campaign was devoted almost solely to the base scenario.
The (petro)chemical industry held its own campaign also in 1990. This campaign was heavily
criticised by local authorities and experts because of its trifling tone and the underestimation of
risks in the distributed written material.

A second and third campaign of local authorities was held in the Rijnmond area in respectively
March 1993 and June 1998. Both campaigns devoted extensive attention to the base scenario and
to the Seveso-type information. A brochure was distributed to all 1.2 million inhabitants of the
Rijnmond region. In both years, the front of the brochure was a photo of a chemical fire. The
centre of the brochure was a map of the area with all (almost 50) 'Seveso' facilities and the main
transport routes of dangerous goods clearly depicted. Next to the map, additional information
about the 'Seveso' facilities was given. Only in 1993, also a 'safety newspaper' was distributed.
It contained additional information on the 'Seveso' facilities and interviews with several persons,
including people critical of chemical industry and (local) government.
During preparation of the 1993 campaign, some 'Seveso' facilities objected against the inclusion
of information on risk sources and other 'alarming' and 'critical' information. They were afraid it
would frighten people or that the image of companies would be damaged.

All campaigns of local authorities were evaluated (van Duin 1990, Woudenberg 1994, Mos
1998). The campaigns led to a substantial increase in knowledge of the base scenario by the
inhabitants. The campaigns also made people more aware of the possibility of disaster. However,
no campaign led to an increase of fear. The extra critical 1993 campaign led to a small decrease
of fear (see table 1 below). Considering the total number of inhabitants (1.2 million) a decrease
of 5% (60,000 persons) feeling not very safe or not safe at all can be called significant. The most
likely explanation for the decreased fears is that people found responsible authorities more open
after the campaign. Especially the map was valued highly. From the risk perception literature
(Hance et al. 1989, Santos et al. 1996) it is known that a suspicion of withholding information can increase fear.

Table 1.

<table>
<thead>
<tr>
<th></th>
<th>1993 before</th>
<th>1993 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very/totally safe</td>
<td>25</td>
<td>31</td>
</tr>
<tr>
<td>Moderately safe</td>
<td>46</td>
<td>49</td>
</tr>
<tr>
<td>Not very safe/not safe at all</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>No answer</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Except for that map with all risk sources in the region, people showed very little interest in other risk data that were shown. People were mainly interested in the information related to readiness, especially the possibilities of escape. After the campaign, people were more critical about the possibilities of rescue services to mitigate consequences of a disaster. At the same time, (see table 2) their tendency to perform actions that run counter the base scenario, like escaping and using the telephone, decreased significantly and permanently.

Table 2.

<table>
<thead>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Of which Fleeing</td>
<td>13</td>
<td>4</td>
<td>1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

An interesting picture concerning Otway's contrast between readiness and reassurance develops. The explicit information used in the campaign material made people more alert and also made them more critical about the mitigating possibilities of rescue services. At the same time, they did not become more fearful and they showed a increased tendency to perform the somewhat strenuous behaviour prescribed by the base scenario. In fact, these data show that readiness and reassurance do not stand in opposition, but closely work together. Open, 'vivid' information to prepare people for disaster does not have to frighten them and can increase the tendency of people to follow 'unnatural' governmental instructions better.

INFORMATION DURING AN INCIDENT

Time constraints during an incident are extreme. Communication can then easily become a struggle between demands of correctness, completeness and timeliness. Local authorities may be inclined to stress the two first demands and to grant the last one less priority. As a consequence they can be very reluctant to disseminate information quickly during an incident. Several reasons for this reluctance exist. A very important reason is the fear for panic. Many people in command hold the opinion that the 'clear, vivid and catastrophic images of disaster' Otway mentions, will lead to panic in the public. Panic can greatly increase the negative impact of the incident or may become damaging in itself. Another reason is the wish to reduce uncertainties and fear of making mistakes. Incident management is almost equivalent to deciding under uncertainty. Responsible authorities want to reduce uncertainties maximally before making a decision. This implies gathering and waiting for information and thus waiting with disseminating information. The wish to reduce uncertainty can be reinforced by fear of making mistakes or fear for claims by third parties. A last reason for waiting with giving information is simply that responsible people (the mayor, civil servants and even the chief of the fire brigade) are also people. Their primary interest is the welfare of the community. An incident is a serious disruption of normal daily routine. As with the loss of a beloved, they resist such disruption and must go through a period of denial. With some, this period can take (very) long.
A large body of literature shows that panic is a very rare phenomenon during incidents (see Auf der Heide 1989, Mileti et al. 1975, Quarantelli 1990, Fischer 1994). Panic occurs if there is an immediate and serious threat to health, if people cannot escape from this threat and if they are unreachable for help by others. A fire in a disco or a stampede in a football stadium satisfy these conditions, but a fire in a chemical plant will seldom do. Several experiences in the Rijnmond area confirm the absence of panic during incidents and also show that waiting with disseminating information can be counterproductive.

A very good example are two incidents at the large Shell plant in the Rotterdam harbour in 1995. Early in the morning of April 12 of that year, a cloud of white powder (catalyst) escaped from Shell. It was carried north by the wind and came down again in a quarter of the city of Schiedam. At first, Shell denied an escape had happened. They made the official, obligatory announcement only after being forced by local authorities. After the initial denial and hesitation with the announcement, Shell emphasised the innocent character of the dust. They stated it resembled natural dust and could only cause a little nuisance. A strong suggestion by the municipal health service that the dust contained several contaminants with possible negative health effects was affirmed by Shell only after several hours of waiting and discussion. A local citizens group was greatly disturbed by the way the incident was handled. They spoke of 'hushing up' scenarios. Their complaints led to an official investigation by the inspectorate for the environment.

September the 25th, again early in the morning, another incident occurred at the Shell plant. A storage tank with crude oil ruptured. About 4 million litres of oil burst out of the tank. Drops of oil fell down on houses, playgrounds, roads and cars south of the plant in Hoogvliet, a quarter of the city of Rotterdam. This time, Shell, in close co-operation with the environmental and health services, drew up a letter for the inhabitants of Hoogvliet. In the letter it was stated that the oil was contaminated with several chemicals, including carcinogenic ones. This meant a breakthrough in openness. No company or even local authority had ever communicated anything to the public about carcinogenic effects of chemicals during or shortly after an incident. Shell was the first in Rijnmond. This time, citizen groups did not make allegations of hiding up. The inspectorate for the environment did not consider an investigation. Maybe more importantly, no citizen of Hoogvliet panicked or even showed signs of fear when they called the special telephone number that was opened. Most questions concerned the free service for cleaning cars Shell had installed.

CONCLUSIONS
The data and examples shown in the present article cast doubt on the opposition between readiness and reassurance as supposed by Otway. Stress research shows that people can cope with threats effectively. People have difficulty however, in coping with uncontrollability and unpredictability. Industrial risks are uncontrollable to a large extent. People feel offended if authorities pretend that disasters can be controlled and predicted (as in risk evaluations) and become more afraid if they think information is withheld. Many respondents in the Rijnmond studies remarked that they were not stupid and that they knew they were living in a risky environment. Emotions of people are geared at industries and authorities trying to cover up and not at the risks per se. In recent years, risk communication in Rijnmond has become more open. This has resulted in increased trust and a small, but significant decrease of fear in the general public. These effects are now robust enough to allow the main conclusion of this article: openness does not cause panic, but alleviates fear.
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NEWSPAPER REPORTING OF RISKS IN THE UK AND SWEDEN

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Public understanding of risks is likely to be informed by the media. We report a cross-national study looking at how newspapers in Sweden and the UK characterize a variety of risks, focusing on a two month period surrounding the 10th anniversary of the Chernobyl accident. Approximately four times as many reports about risks (per newspaper) were found in Sweden as in the UK, possibly reflecting a Swedish culture of safety. The Bovine Spongiform Encephalopathy (BSE) crisis dominated reporting in both countries, especially in the UK. The proportion of reports on Chernobyl, and the pattern of reporting, was similar across both countries, although in Sweden there was an increase in reports about other nuclear hazards after the anniversary, suggesting that generalization of media concern may have occurred. Generally, BSE was discussed using a greater number of characterizations in the UK, while Chernobyl was reported using more characterizations in Sweden. Reports about hazards tended to be alarmist rather than reassuring, and rarely used statistics to express degrees of risk. Ongoing work is attempting to compare data on public risk perceptions to the media portrayals of risk discussed here.
AUDIENCE-BASED COMMUNICATION –
THE ILLUSION OF GROUP MENTAL MODELS?

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Audience-centred risk communication has recently received increased attention as more
traditional expert-based approaches struggle to deliver convincing results in practical
applications. Although psychometric studies have tried to incorporate the sociological
component delivered by cultural theory in order to improve targeting and communication
efforts, the notions of trust, blame and power, particularly in a media context, are being
increasingly recognised as important and difficult to accommodate in the traditional
theoretical framework.

This paper develops a qualitative approach to isolate common nodes in people’s mental
models related to media perception and appraisal at a macro level which in turn lead to
distinct patterns of media selection and information retrieval. Results of focus group meetings,
in-depth interviews and individual and group experiments indicate that people from different
socio-economic backgrounds display similarities with regard to trust in information sources,
understanding and attitudes towards power and the process of assigning blame.

The idea of group mental models is explored and appears to be a potentially useful means of
improving risk communication on a larger scale. Further research rooted in a wider set of
target groups is in progress and will address the relation between group characteristics and
other more readily identifiable variables to enable mental model identification within a large
group or community.
TRACK 3

SESSION 4

SOCIAL AMPLIFICATION - BACKGROUNDS
Audience-centered risk communication has recently received increased attention in view of communication's unprecedented approach to delivering information to targeted applications. Although psychological studies have used an audience-centered methodology to understand the psychological and sociological implications of risk communication, there is limited understanding of the audience's needs and perceptions. This paper describes an evaluative study of risk communication in the context of the audience's needs and perceptions. The study was conducted through in-depth interviews and focus groups with community members to identify the audience's needs and perceptions. The findings suggest that audience-centered risk communication can be effective in improving public understanding and reducing anxiety. The study highlights the importance of tailoring risk communication to the audience's needs and perceptions.
SOCIAL CAPITAL AND TRUST IN A BIOMASS PLANT PLANNING CONSULTATION

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This paper outlines findings from interview and questionnaire research carried out in Sutton, Cambridgeshire, UK in May 1998, where a planning consultation for a biomass (straw burning) plant took place between January 1994 and February 1996. A measure of social capital based on membership of voluntary associations is constructed and discriminant functions are derived from the social capital measure, education level and age, to fit replies to questions relating to trust in five parties involved in the planning debate (the developer, the local planning authority, the parish council, the local media and environmental groups). Respondents' trust in these five parties is also related to issues such as perceived fairness, risk communication, public participation and social amplification. It is found that while the measure of social capital used may be a good predictor of agreement with the statement “most people can be trusted”, it is not such a good predictor of trust in the specific parties. The usefulness of the social capital concept for predicting trust behaviour in such planning debates is then assessed.

INTRODUCTION

Biomass is seen by many EU countries as an energy source whose further development it is desirable to encourage (whilst in 1995 total EU biomass capacity was estimated at 3500MW, in 1997 the EU adopted a target of 10,000MW of new installations by 2010 (COM, 1997)). In Finland, Sweden and Austria in 1997 biomass accounted for 23%, 18% and 12% respectively of primary energy use, but its market share is considerably less in other European countries (COM, 1997). In the USA a broadly comparable statistic is 4% (Hall, 1997).

In the UK, research into the poor commissioning rates of all types of renewable energy plants has found that the greatest obstacle is obtaining planning consent (AEP, 1995, 1996; Williams and Limbrick, 1995; Jackson and Löfstedt, 1998). Unfortunately, very few biomass cases were included in these surveys owing to the fledgling nature of the industry. Nevertheless, anecdotal evidence and case studies suggest that here also, planning consent is likely to be the greatest obstacle (Billins, 1998; Hargreaves, 1996; Sinclair, 1998).

Many case studies have investigated attempts to gain planning permission for a wide variety of unwelcome facilities. A number of these emphasise the importance of the role of trust between the principal parties (Renn et al, 1996; Löfstedt, 1996a, 1996b, 1999a; Kunreuther et al, 1993, 1996; Linnerooth-Bayer and Fitzgerald, 1996; Kasperson et al, 1992; Flynn and Slovic, 1993). Some sociologists and political economists have associated the engendering of trust with the presence of social capital (Coleman, 1988, 1990; Fukuyama, 1995; Putnam, 1993a, 1993b, 1995a, 1995b). Therefore there may be a link between commonly used measures of social capital and the levels of trust between the principal parties in unwelcome facility planning debates.

This paper presents results of social research carried out in May 1998 at Sutton, Cambridgeshire, one mile from the site of a proposed 31MW straw burning plant. The
European Development Corporation (EDC) applied for permission to site the plant in late 1993 on the Elean Business Park between the villages of Sutton, Witcham and Mepal. The plant gained a NFFO-3 (Non-Fossil Fuel Obligation, 3rd round) licence in December 1994, was refused planning permission in September 1995 and finally obtained permission in February 1996. Face-to-face questionnaire research is used to evaluate local residents' trust in five parties in the planning debate (the developer, the local planning authority, the parish council, the local media and environmental groups) and to compare it to such issues as perceived fairness, risk communication, public participation and social amplification. A measure of social capital is also constructed as the extent of involvement or membership of local community groups, following that used by Putnam (1995a, 1995b). This is correlated with agreement with the statement "most people can be trusted" (again following the methodology of Putnam (1995a)), and also with measured levels of trust in the five parties.

**METHODS AND AIMS**

Sixty Sutton residents were interviewed on three consecutive days between 9 am and 7 pm in mid-May 1998 outside the village mini-supermarket using a convenience sample methodology. The sample included 36 females and 24 males with an age and education distribution representative of the area. A large proportion had lived in Sutton for many years and had other family members in Sutton and there was a high level of home ownership (62%). These factors, together with information from in-depth interviews with six local people, indicated that Sutton is a densely tied, close-knit community. Altogether 78 people were approached in the survey. Four of these were not residents of Sutton and three had not lived long enough in Sutton to qualify for completion of the questionnaire. Additionally, eleven people refused to answer.

The social capital measure used, as in Putnam (1995a), was the number of local voluntary associations and community groups of which the respondent was a member, chosen from a comprehensive list procured from the local library (though other local organisations mentioned by respondents were included). In the face-to-face interviews, questions about trust were asked in the second half of the questionnaire. By then it was believed that rapport would have grown. The subjects were asked directly in each case whether they trusted the parties and then, as follow-up questions, to explain their responses.

As well as the face-to-face questionnaire and in-depth interviews, a 'content analysis' of local newspapers over the period from January 1994 to December 1996 was carried out. The method used followed that suggested by Priest (1996). The purpose was to find out if any of the events in the debate received exceptional press coverage that then caused 'secondary impacts'. Examples of such media influence on social attitudes in public debates involving risk-taking decisions are well documented in the literature of risk analysis and are said to exhibit 'social amplification'. Such social amplification has been shown to have an influence on trust between parties (Kasperson et al, 1988; Renn et al, 1992), hence its importance in this study.

The principal aims of the research were:

1. to test the relationship between involvement in local associations and agreement with the statement "most people can be trusted", following the methodology of Putnam (1995a);
2. to investigate the relationship between involvement in local associations and trust in the specific parties, and hence to assess the usefulness of Putnam's social capital definition for predicting trust behaviour; and
(3) to investigate to what extent trust related to the issues of fairness, risk communication, public participation and social amplification. These have been shown to have relevance in many cases of the siting of unwelcome facilities, such as those documented by Linnerooth-Bayer and Fitzgerald (1996), Renn et al (1996) and Löfstedt (1996a, 1996b, 1999a).

**RESULTS**

Stated levels of trust in the five parties followed a pattern typical of many unwelcome facility planning debates, with local and environmental groups and the local media receiving the highest support, the planning authority less and the developer the least. Levels of voluntary association membership varied from 0 to 7 associations with an average of 1.35.

Putnam (1995a) found that the three independent variables education, race and age were correlated with this social capital measure. Race was not measurable as a variable in this survey, owing to the low percentage of ethnic minority groups in Cambridgeshire. There was no evidence in this study itself to support the existence of correlations of social capital with education and age. However, for comparability, education and age were taken as independent variables, together with the social capital measure, in carrying out discriminant function analyses (DFAs) to discover whether social capital can be used as a predictor of trust behaviour. The first test was whether there was a relationship between involvement in local associations and agreement with the statement “most people can be trusted”. The results are shown in Table 1:

<table>
<thead>
<tr>
<th>Function</th>
<th>Wilks' Lambda</th>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.840</td>
<td>9.862</td>
<td>3</td>
<td>0.020</td>
</tr>
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</table>

**Table 1 ‘Most people can be trusted’**

| Social capital | 0.621 |
| Education level | -0.738 |
| Age | 0.294 |

The absolute values of the standardised canonical discriminant function coefficients (SCDFCs) show the importance of the three independent variables in the trust measure (Hair, Anderson, Tatham and Black, p. 269). Table 1 confirms the relationship between voluntary association membership and agreement with the statement “most people can be trusted” with these independent variables, with 2% significance, though education appears to be a more significant variable than social capital. These findings are not inconsistent with those from Putnam (1995a).

However it is more instructive to perform DFAs where the discriminant functions are the specific parties' trust levels, for if the social capital concept is to be of any use at all it needs to be a predictor of trust in specific situations. Table 2 does not find significance in predicting trust in the developer and in this case the SCDFC is extremely low, indicating that social capital may almost be an irrelevant factor in determining trust behaviour.
Table 2 Trust developer

<table>
<thead>
<tr>
<th>Function</th>
<th>Wilks' Lambda</th>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8176</td>
<td>0.781</td>
<td>3</td>
<td>0.079</td>
</tr>
</tbody>
</table>

Standardized Canonical Discriminant Function Coefficients

| Social capital | -0.007 |
| Social capital | 0.970 |
| Age           | -0.482 |

Four other similar DFAs were performed and found significance levels for trust as follows: local planning authority 73%, parish council 38%, local media 46% and environmental groups 21%. This indicates the likelihood of a considerably smaller effect size than occurred in the test of agreement with the statement “most people can be trusted”. Hence it appears that the usefulness of the social capital concept as defined by membership of local voluntary associations and community groups may be extremely limited in terms of predicting trust behaviour in practice.

Other determinants of trust were therefore investigated. Table 3 shows Spearman correlations and significance levels between trust in the developer and responses to four statements relating to perceived fairness, risk communication, public participation and social amplification.

Table 3 Trust in the developer and agreement with specific statements

<table>
<thead>
<tr>
<th></th>
<th>Spearman's rho</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 'It is fair to site the plant in Sutton'</td>
<td>0.567</td>
<td>0.0%</td>
</tr>
<tr>
<td>2. 'The developer did not try to engage in dialogue'</td>
<td>-0.303</td>
<td>8.6%</td>
</tr>
<tr>
<td>3. 'The public should be allowed to participate more in decisions of this type'</td>
<td>-0.253</td>
<td>14.2%</td>
</tr>
<tr>
<td>4. 'The local media exaggerated aspects of the debate'</td>
<td>0.130</td>
<td>48.6%</td>
</tr>
</tbody>
</table>

It was found that perceived fairness was highly significant and that the risk communication item nearly achieved significance. The poor significance of the public participation item can be attributed to the fact that as few as three respondents disagreed with it, while item four is likely to be insignificant owing to the perceived low influence of the media in the debate. Similar correlations to Table 3 were carried out relating these specific statements to trust in the other parties in the debate. No significant results were obtained in these cases.

DISCUSSION

This case study suggests that measures of social capital derived from involvement in local voluntary associations and community groups are not likely to prove very useful in predicting trust behaviour in such circumstances. The issue of fairness was discovered to be considerably more likely to be useful in predicting the trust of local residents in the developer. Furthermore, other factors such as risk communication, public participation and social amplification, although not shown to be strongly related here, have been found to be important in other case studies (Linnerooth-Bayer and Fitzgerald, 1996; Flynn and Slovic, 1993; Lofstedt, 1996a, 1996b, 1999a; Renn et al, 1996).
Nevertheless, social capital can be viewed in different terms and in different contexts: it is possible that more recent approaches will prove fruitful. Six (1998), for example, suggests that networks of civic engagement may take shape in voluntary organisations because there is concerted mutual distrust towards something. In the case of Sutton, a local organisation known as WAG (the Witcham Action Group) co-ordinated opposition to the plant siting (WAG, 1994). Coleman (1988) said that social capital can be specific in this way and talked of the concept of groups being appropriate for action in the pursuit of other causes (WAG had been formed from the core of the Parish Council). Thus in the Sutton study it is possible that at least some of the local social capital had grown from opposition to the proposal.

Löfstedt (1999b), in support of this possibility, proposes that:

‘... networks of civic engagement do not always form in pleasant circumstances, but during a crisis with high levels of distrust, drama or controversy ... such networks may increase community building on the local level, but may not necessarily increase trust within society as a whole’ (Löfstedt, 1999b).

Six (1998) proposed a model in which a community’s cultural trust presumption could be classified as fatalist, an enclave, a hierarchy or individualist. Sutton’s densely tied, close-knit community makes it, in Six’s terminology, an enclave. In such circumstances Six expects:

‘the kinds of dense and durable regional or local economic relationships that are classified by conventional social capital theory as high in social capital, but which cannot be “rolled out” to the whole of society’ (Six, 1998).

Results in Sutton bore this out with the parish council being most trusted, followed by the local planning authority and finally the developer. Six’s model is therefore supported as descriptive of community trust behaviour.

Cultural models of this type are, however, suspect as explanatory models of behaviour, since cultural variables arise to a large degree on context (Thompson et al, 1990) and change with it (Dake and Thompson, 1993). Cultural theory is known to link behaviour with whatever worldview is predominant in the individual at the time (Adams, 1995). Therefore the cultural worldview, which changes dynamically with contextual factors such as fairness, risk communication and so on, is not of itself likely to predict trust behaviour unless it is incorporated in a wider model including these factors.

Putnam (1993b, p. 90) claimed that ‘taking part in a choral society or bird-watching club can teach self-discipline and an appreciation for the joys of successful collaboration’. Putzel (1997) has questioned the positive effects of such associational membership, asking to what end the self-discipline and collaboration is gained. Levi (1996) claims that a more precise definition of trust is required, distinguishing between interpersonal, organisational and governmental trust. Since the statement "most people can be trusted" may imply trust on an interpersonal level, to be contrasted with this study’s other questions concerning trust in specific organisations, there may be benefits from exploring Levi’s suggestion. It seems likely in any event that Putnam’s approach is too simplistic, although, as Levi said, it has helped transform the agenda of social science in a healthy and productive way.
CONCLUSIONS

Social scientists' attempts to relate trust behaviour to levels of membership of voluntary associations remain unsatisfactory. This case study supports recent fieldwork in finding other contextual factors, such as perceived fairness, risk communication, public participation and social amplification, at least as important in determining trust. A successful model of trust based on social capital is likely to need to incorporate these other contextual factors.

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HAZARD SEQUENCES: THE EFFECTS ON RISK AMPLIFICATION

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Within the social amplification of risk model, intensification and attenuation of a hazard’s psychological and socio-economic impacts are a product of a variety of social and cultural processes. These may result in ‘secondary’ effects, for example in relation to regulation, liability, stigmatisation and loss of confidence in companies and institutions. This may ultimately result in third order impacts such that the significance of initially unrelated hazards is also affected. However, the ways in which the perception of one hazard may affect perceptions of subsequent hazards remain unspecified.

This issue is explored here in relation to two case studies drawing on data from media coverage of the hazards and official government policy statements in addition to information on public behaviour changes. The first relates to the Pill and the second to Hormone Replacement Therapy (HRT). In October of 1995 the UK Committee on the Safety of Medicines announced that there was an increased chance of a thrombosis associated with particular types of oral contraceptives. Although the evidence for this was disputed, the content and management of this announcement is said to have led many women to stop taking the Pill, subsequently linked with a rise in teenage pregnancies and in the abortion rate. Later media coverage of scientific evidence and statements by the Department of Health concerning links between the Pill and HRT with breast cancer have not led to impacts of a similar magnitude.

These case studies are used to illustrate how amplification processes associated with a particular risk event may de-sensitise public perceptions such that the risks of subsequent hazards are attenuated. It is suggested that the extent to which the impact of the initial hazard persists and becomes “normalized” is a key factor in understanding the apparent lack of impacts associated with subsequent hazards.
DEFINING TRUST

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The trust concept is today a popular one within western societies. There is a belief, largely based on opinion poll data, that public trust toward policy makers is declining. But what is trust? There are supposedly at least 32 definitions of the world! In this study, funded by the Swedish Council for the Planning and Coordination of Research, we used the same questions as those used by Swedish polling institutes (particularly SOM) regarding the topic of the respondent's (public's) trust towards policy makers. However, rather than using a quantitative approach, we used a qualitative one in which we asked 30 individuals (in-depth face-to-face interviews) in Båstad, what the questions meant for them. The findings of our study showed that the public in this study had different definitions of the term than those of the opinion polls interpreters and designers. These findings, if they can be replicated, leads to the questioning of whether public trust towards policy makers in western societies is actually decreasing as much as opinion pollsters would like us to believe.
PUBLIC PERCEPTIONS OF AGRICULTURAL BIOTECHNOLOGY: ETHICS, RISK AND POWER

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Recent developments in agricultural biotechnology have met with considerable ambivalence and disquiet among various European publics. This disquiet increasingly has led to public criticism of this new technology and rejection of its products. In the UK in particular, research has shown a deepening antipathy towards the technology and, importantly, towards those who are responsible for its development and control. This antipathy is set in the context of successive waves of critical media coverage of the issues and widespread campaigns of direct action against both producers and retailers of genetically modified crops and foods.

The climate of public hostility towards the technology has created a problem for government, which is otherwise committed to promoting what promises to be an economically significant technological sector. It has also applied a brake to the development and commercialisation activities of the producers of genetically modified seeds and foods. All of these actors are now looking for a better understanding of this overwhelmingly negative public response.

Much of the current research on public perceptions of agricultural biotechnology makes a clear distinction between risk perceptions and ethical concerns. Indeed, an often-expressed view is that 'the public's' primary concerns are about 'ethical' aspects of the technology. In this paper, drawing on focus group research being carried out in the context of an ongoing comparative study, we take a critical look at public views of agricultural biotechnology. Public views are understandably complex, because the issue has become a focus for public concerns about a diverse range of wider issues, including science, technology, the power of industry, government and regulation, and food. As well as analysing the key issues raised, we question the distinction between 'risk perceptions' and 'ethics' that enables substantive public concerns to be misrepresented and sidelined in the debate about the risks of biotechnology.
THE RISK SOCIETY:
PERSPECTIVES FROM SOCIAL AMPLIFICATION RESEARCH

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ABSTRACT
In 1986, Ulrich Beck coined the term “risk society” to denote a society in which allocations and dispositions of risk supplanted wealth distributions as the primary concern and focus of sociopolitical institutions. This work drew heavily upon the tradition of German social theory but made only limited reference to the risk literature.

Tapping studies on the social amplification of risk and related work, this paper explores the notion of a risk society by examining long-term trends that are shaping new risk challenges and altering social approaches to risk. First, as risk increasingly emanates from global and transboundary sources, it is apparent that society’s risk portfolios are changing. Meanwhile, cybernetic and lifestyle risks are increasingly exacerbating or displacing traditional health and safety hazards. Public expectations and values are also altering the attitudes to technology and economic growth that have prevailed through much of the 20th century. Ever-mounting democratization of society has placed new demands on social and political institutions at a time when available stocks of social capital often appear commensurate to the expected capability and performance. And the social ethics that underpin current risk management approaches are also undergoing transformation.

The authors inquire into the implications of such changes for the future role of risk issues, for changing policy and legal approaches that may be expected, and for patterns of social conflict and institutional transformation.

INTRODUCTION
In 1986, Ulrich Beck published Risikogesellschaft: Auf den Weg in eine andere Moderne, subsequently translated as Risk Society: Toward a new modernity in 1992. He envisioned a stage of modernity in which the hazards produced in the growth of society become predominant, the relationship of society to hazards exceeds the bases of social conceptions of security, and the allocations and dispositions of risk supplant the distribution of wealth as the primary concern and focus of sociopolitical institutions.

Setting aside for the moment the particular theoretical propositions that Beck argues in support of the notion of the risk society, a host of questions abound as to how the risk
challenges to society are in fact changing (of which Beck says relatively little), how the societal context in which risks are addressed and managed is being transformed, and what this means for the institutions responsible for the risk-management function. Whereas Beck consults social theory as the basis for his formulation of the concept of the risk society, we explore the past decade of empirical research and theorizing in the broad domain of what we have previously described as the social amplification of risk (Kasperson, Renn, Slovic et al. 1988; Kasperson and Kasperson 1996; Kasperson, Kasperson, Pidgeon, and Slovic 1999) to discern trends relevant to these issues.

CHANGING RISK PORTFOLIOS

The first major trend of significance is the changing nature of risks facing society. First risk portfolios facing future society are becoming more and more dominated by risks emanating from outside established political jurisdictions. So in a world with a rapidly growing and interactive global economy, transboundary risks and global environmental problems will progressively consume more and more of society’s diagnostic, assessment, and management resources. Human-induced climate change, not the radiation hazards that preoccupy Beck, is the archetypical risk problem of the future, with its slow accumulation, diffuse sources, large uncertainties and potential nonlinear relationships, opaque impacts and poor resolution of predictive models, and strong interaction with contentious value and ethical questions. Second, and related to the above, future risks will increasingly be the byproduct of multinational corporation that lie beyond the clear jurisdiction of nation-states. The generation of risk is almost certain to undergo progressive concentration and centralization even as the monitoring and control of risk will steadily accrue to the political domain—the international arena—where institutional monitoring and control systems are weakest and most diffuse, and where inequalities hold the greatest potential to impede action.

Third, three great domains—release of energy, materials, and information—underlie societal portfolios of risk. The side effects of the use of energy and materials have dominated the 20th century, but future societies will find their risk-related activities increasingly dominated by cybernetic hazards. It is abundantly evident that the rapid advances in genetic engineering, computer technology, massive data bases, and global communication systems constitute a new risk wave, and the speed with which new threats are emerging or changing in scope and potential consequences are rapidly outstripping the capacity of legal and other institutional systems to change at the required pace.

Finally, many of these hazards, and even including a number of the more established energy and material risks, fall into what Erikson (1995) terms a “new species of trouble.” Many of these hazards are invisible to the senses. Large uncertainties and opaque future effects leave issues unresolved and destined to continue indefinitely into the future. Not only do they register unknown effects on those who bear the risks but they destroy the social capital needed for the effective functioning of society (see below).

DISSOCIATION, NOT BOOMERANG

Sooner, or later, Beck (1992, 37) argues, risks catch up with those who produce or profit from them. Latent side effects, in this view, strike back at the centers of production and the agents of modernization find themselves caught in the maelstrom of hazard that they create.

Would it were so, for this would greatly simplify risk-management challenges. To the extent that risk genesis carries with it the price of adverse consequences, the basis exists for
negotiating social pathways for accommodating risk. In fact, the hallmark of emerging risk problems and human relations with nature is the extraordinary export of risk from the centers of economic production and consumption to remote marginal peoples and to unborn generations. A major finding of our *Regions at Risk* (Kasperson, Kasperson, and Turner 1995) in which we examined environmental degradation in nine regions around the world was the extensive “masking” of the drawdown of nature due to the export of most of the damage to future generations. Similarly, it is now widely recognized that analyses of emerging critical environmental situations require an “open systems” approach because of the extensive spatial connection between the sources of risk and the areas and peoples that bear the consequences.

The implication of growing temporal and spatial dissociation is to encourage risk displacement and impede the internalization of risk into production, consumption, and public policy.

**SOCIAL TRANSFORMATIONS**

Simultaneous with changing risk portfolios and growing risk dissociation are numerous trends of social transformation that are altering the sociopolitical contexts and institutions in which risk is embedded. A full analysis of these changes is well beyond the scope of this brief paper. Accordingly, we mention three—shifting societal values, democratization processes, and shrinking social capital—to illustrate how trends of societal change are interacting with altered risk.

First, as Inglehart (1997) argues in his well-known work *Modernization and Postmodernization*, the societal values that provided the motor force in the emergence of industrial society—economic achievement motivation, economic growth, and economic rationality—are giving way to values associated with diminished faith in science, technology, and authority, and increased concern with well-being and quality of life. This shift underlies, and contributes to, the oft-noted paradox of people becoming more risk averse as they become healthier and safer. This trend is likely to continue to intensify, assuring that future societies are likely to expend progressively greater resources for risk minimization, with increasing public dissatisfaction and escalating demands for protection the likely results.

Secondly, at the beginning of the 21st century, it is abundantly apparent that we are in the midst of a worldwide democratization movement. Across societies, public expectations have changed concerning the expectation of “interested and affected” parties to be consulted in risk decisions. The clarion call is out for “openness,” “transparency,” and “stakeholder participation,” far in advance of our knowledge of how improving democratic procedures can actually be achieved and what outcomes are likely to result. Accompanying, and driving this democratization of process are emerging ethical systems concerned with “victimization,” “environmental justice,” and new forms of “environmental colonialism.”

Such altered social processes and public values place growing demands upon institutional processes and particularly available reservoirs of social capital. Levels of social trust are a primary form of such social capital. Recent empirical risk studies across numerous societies have documented how social distrust interacts with public perceptions of risk to complicate the negotiation of risk matters and to accelerate growing levels of risk aversion and opposition to technology. Such distrust is a prime driver of the social amplification of risk and it appears likely that the emerging risk society may be one in which dealing with a high density of
socially amplified risks will significantly alter existing assessment and management processes.

CONVERGING TRENDS AND THE RISK SOCIETY
The discussion above, in this brief paper, can only be suggestive. But we set forth the argument that the risks facing society and the social contexts in which they are addressed are changing in ways that are often antagonistic and confounding, and are extensively shaping the risk management function. There is a growing recognition that something is badly amiss in risk management—authoritative decisions are no longer accepted, public alarm accompanies risks that seem minor, some risk problems seem inherently unpredictable in their social import, prioritization schemes don’t work, many risk controversies never get settled.

As yet the fundamental reshaping of risk problems and their solutions are only dimly perceived. In the United States, the 1980s were a time of hope for risk communication solutions; the 1990s the era of “stakeholder involvement.” Both are flawed in what can be achieved. Meanwhile, Europe appears to be in a growing embrace of ethical mandates—the “polluter pays” and “precautionary” principles. In both North America and Europe, we tinker with our institutions to find new modes of addressing changing risks and societal contexts. As yet, these appear to be surficial efforts to cope with the deeper challenges posed by an emergent risk society.

REFERENCES


TRACK 3

SESSION 5

RISK COMMUNICATION: INDIVIDUAL AND INSTITUTIONAL
CONVERGING TRENDS AND THE RISK SOCIETY

The discussions above in this brief paper can only be suggestive but we are led to the conclusion that the risks facing society and the social systems in which they are embedded are changing in ways that are often unpredictable and unsatisfactory, and this uncertainty shapes the risk management processes. There is a growing recognition that something as seemingly as risk management—which is defined by the objective and quantifiable assessment of risks—may not be sufficient in many cases to ensure the safety and security of the social systems where these risks are embedded.

As yet the fundamental reorientation of risk problems and their solutions are only dimly perceived. In the United States, the 1980s were a time of hope for the risk management paradigm; the 1990s the era of disillusionment. The 1980s were flawed in what was the unending commitment in what was an era of deinstitutionalization—the "politics of cutbacks" and "programming" paradigm. In both North America and Europe, we witness with our institutions in their role models of addressing changing risks and societal concerns. As yet, there appear to be superficial solutions to cope with the deeper challenges posed by the emerging risk society.

RISK COMMUNICATION


ENVIRONMENTAL RISK PERCEPTION, HEALTH CONCERNS AND ATTITUDES FOR CHANGE

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ABSTRACT

This study explored how the level and characteristics of environmental risk perception influence the individual’s attitude to take concrete measures for change. It is known that environmental risk perception depends on different factors like knowledge about the consequences and influence on humans, severity of consequences and controllability. Additional factors have been found to have significant relation to environmental risk perception and especially to the attitude for participation in ecological improvement. These factors were: 1) perceived personal health and 2) different aspects of the socio-economic status. It was found that socio-economic status tends to divide people according to their attitude to participate in a program for risk reduction and change. Important policy implications and risk communication issues are discussed.

INTRODUCTION

The present research is motivated as aiming to contribute in policy and decision making by the examination of how people evaluate and judge societal risks today. Public awareness of risks calls for valid information and adequate safety standards. In Bulgaria, where the level of objective risk is high, risk communication issues are not appropriately organized. There is a big gap between the efforts of the responsible institutions to take measures for situation improvement and the public response towards the different kinds of risks. The great demand for risk mitigation is usually accompanied by non-involvement and apathy while it is necessary to participate actively in programs for situation improvement. In order to understand this public attitude, it is important to see how different socio-economic factors influence the perception of risks.

The main objective of this study was to investigate the perception of environmental risks in Bulgaria as it is related to health and material state of the people from four sites in the country: Sofia and Pernik (West Bulgaria), Varna and Devnja (East Bulgaria). These sites are industrial regions, which reflect the undergoing economic and social changes and the acute economic crisis in the country. They are chosen in order to investigate the influence of the economic crisis (closed plants, inflation of the work force, unemployment) on the level of risk perception and health state of the population.

METHODOLOGY

The research methodology consisted of two parts: 1) qualitative research (semi-structured interviews and focus groups discussions; 2) quantitative data collection (survey designed by using the qualitative data results).

The semi-structured interviews covered 23 individual interviews with stakeholders from the study areas: local governments’ officials, public health doctors, labour unionists or workers,
plant managers, social workers, NGOs’ representatives or journalists. The focus group discussions were used also as additional method in the study areas. It contributed to research validity and helped to develop understanding of environmental pollution risk perception. The semi-structured interviews and the focus groups discussions covered the following topics: general problems and the problems of the region; environmental problems in the study area family and personal problems; health and material problems; trust in authorities; opinion about responsibility; media publicity and availability of information about the ecological state of the region; controllability of exposures; suggestions for situation improvement.

A Risk Perception Questionnaire Survey, with closed-answer questions, was designed to be able to compare more formally the level of concern about different social and environmental issues in the 4 study areas. The subjects were 748 individuals participating in a random sample, 489 females and 253 males. Mean age of the respondents was 36 years, their education varied from basic to university and their socio-economic status was quite different. The content of the questionnaire included a section for judging risk with regard to society, some sections asking for judgements of subset of risks with regard to two targets: the respondent him- or herself (personal risk), or people in general (general risk). The respondents had to rate several dimensions, such as perceived control over a risk, probability of harm, questions about trust in institutions and media; questions about material state of the family where several indicators for material deprivation have been used: (persons unemployed, households overcrowded, households not owner-occupied, household with no car, household with incomes lower than the official existent-minimum for the country), questions about health state (permanent sickness or disabilities, long-standing illness, etc.) and demographic characteristics.

RESULTS
The analysis of interviews, focus group discussions and surveys supported the main expectation of the research: to provide the relations between the risk perception, the health state and the material conditions of life. It was found that the people, who experience negative tendencies in their life (the situation has become worse) expressed higher level of risk perception and stronger demand for risk mitigation.

It could be said that one of the most important observations in the research was that the level of perceived risks, created by the society, was very high. It appears reasonable to conclude that the objective risk levels of the real risks in Bulgaria today is the main determinant of perceived risk in the present study. The respondents judged many of the social problems as created because of the socio-economic situation: decreasing of production and unemployment, demographic problem (low birth rate, high death rate, young people leave the country), low quality of life as a whole, low possibility for self-actualization of the professionals. In fact, the objective situation stimulates similar attitudes. The pessimistic media coverage of the economic and social problems in the country and the obvious pauperization of the people because of the low incomes and the high prices of goods, taxes and everything else, contribute for people’s feeling of helplessness to cope with their everyday life problems.

The survey results have shown that the respondents consider themselves personally healthier than people in general. The overall tendency in their answers is that the health situation in the society is worsening. Respondents were most pessimistic about their personal and their families’ health in relation to the expected life continuity, respiratory diseases in adults,
allergies, heart diseases, etc. As to the society, respondents considered as most problematic the expected life continuity, heart diseases, alcoholism, children's health in general, etc.

**Socio-economic status and risk perception**

How the material state influences people's risk perception was a main focus of the research. The results strongly supported the hypothesis that low-income groups have higher sensitivity to risks created by the society. The following tendencies were found.

Risk for life, created by the difficult socio-economic situation in the country, was perceived to be higher by the people defining themselves as poor than by people defining themselves as wealthy or better than average.

The perception of health state was perceived to be worse by the respondents from the 'poor' group in comparison with the respondents from 'wealthy' and 'better than average material state' group.

The lower-income group expressed higher level of personal and societal risk than the higher-income group. There were statistically significant differences between these two groups in the perception of almost all of the 22 personal and societal risks, judged by the respondents. Also the lower-income respondents perceive many risks to be less controllable than the group with higher incomes. These risks were as follows: to be unemployed, to be ill, children to become ill, to be assaulted, not to afford adequate housing, good medical treatment, education and nutritious food, to be poor and others. It was obvious that the sense of helplessness is much more expressed by people with low income than people with high incomes. There was a significant tendency towards higher perceived probability for all of the mentioned risks to occur among the low-income group compared to the high-income group. The low-income group find the risk 'to be injured by the socio-economic situation in the country' to be more involuntary, uncontrollable, unfairly distributed, inaccessible, familiar, new and with dreaded consequences, than the high-income group. These differences were found to be significantly according the T-test for comparison of means.

**Attitudes for change**

The personal involvement or willingness to participate in activities for improvement of the environmental quality was not very high. Respondents answered that they are willing or already participating mostly in the following activities: not smoking in no smoking areas; maintenance of green areas, encouraging the formation of pedestrian zones in the town; not using pesticides in respondents' homes or gardens; not smoking in homes; waste separation of glass, plastics, and paper for recycling.

Generally, most respondents are willing to participate in ecological activities, but only if this participation is not related to any personal inconvenience. The lowest degree of willingness to participate was estimated for activities like limiting the usage of electrical appliances or demanding the government to decrease the traffic.

It was found that the level of health concerns makes difference when people judge the importance of different sources of pollution, outdoor and indoor, and when they think about the costs and benefits of the industrial development. For example, people, perceiving their health condition as very bad, had a tendency to be focussed more on the harms, caused by the industrial pollution and declared stronger willingness to participate in ecological programs. In
the same time, the “bad health” group was more willing to support unlimited use of cars in the cities, than the group, which perceived their health to be good.

Similarly, the economic concerns of the individuals influenced their environmental judgements and attitudes. Respondents, who felt material deprivation, expressed higher level of sensitivity towards risks like industrial pollution, dirty public places, exhausts from motor vehicles and even towards global problems like the depletion of the ozone layer. Surpassingly (having in mind that the green orientation are usually thought to be mainly middle class value) the same group showed stronger attitude to be involved in ecological activities, like maintaining the green parts of the neighborhoods and promoting the idea for pedestrian zones in the cities.

Generally, respondents considered that they are powerless to influence any state policy, but this was especially true for the low-income group. The possibility to influence the public policy connected with the unemployment, the prices of housing, goods, electricity and food, the agricultural policy, education and other aspects of the social life were judged to be lower by the lower-income group in comparison with the higher-income group. This tendency definitely causes lack of action for changed attitudes among people, who are mostly influenced by the economic crisis.

Risk communication and policy implications
The overall opinion is that the responsibility must e taken by the state and its institutions, as Ministry of Labour and Ministry of Environment and Health, Government authorities, central and local, and etc. However, the respondents think that authorities hide part of the information and there were no actions to improve the situation. Mostly credible were mentioned to be the independent experts, the physicians, and the friends.

Strong demand for social, health care and environmental improvements expressed by respondents went together with low intention to contribute with personal efforts in this process. Generally, the respondents were very productive when they had to think about obstacles for taking personal measures to improve their own environment.

The following items have been identified in connection with the process of risk communication in the research areas. First, the responsible institutions should offer the public regular appropriate information and its explanation, including legislation changes, communication, “openness to the problems and their consequences, discussion about the results of each of the possible choices”, creating a situation where “everybody to be ale to share his experience”.

In relation to the environmental problems there was shared opinion that it is important to work with the children, because “they are open to education... there is a need for whole ecological educational program for children”. Other suggestions, like creation of traditions in ecological activities and developing “green line” for community participation in the decision making process were proposed.

Creation of a new partnership among various stakeholders was strongly suggested. It is necessary to facilitate decision-making between different groups that have not experience in participatory policy. All the respondents hoped that future generations would be more involved in decision making and in searching solution for common problems.
PARENTS PERCEPTIONS OF THE IMPACT OF OPENCAST COALMINING ON THE ENVIRONMENT AND HEALTH

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ABSTRACT

The aim of this study is to examine risk perceptions among parents whose children live in close proximity to active open-cast coal mining sites. Parallel to the demise of deep coal mining throughout Britain, has been the development of open-cast mining. This has also been the case in North East England, until recently an area with a long historical and cultural association with deep coal-mining. Many of the open-cast mines, although rural or semi-rural, are close to towns and villages and are developed on 'green-field' sites. In many areas opposition is mounted when planning permission is sought for new sites. In some cases, health risk is cited as a prime reason for opposing such sites, however, the supporting health evidence is contested.

This qualitative study took place in tandem with an epidemiological study investigating the impact of open cast coal mining on children's respiratory health. The study sample is drawn from four semi-rural communities participating in the epidemiological study. Interviews were undertaken with 32 parents, half of whom reported that their children had asthma and all reported concerns about air pollution in a questionnaire survey on the linked epidemiological study.

Results show that a range of opinions prevail within each community. Views ranged from absolutely no concern about the opencast to anxiety about noise, dust, extra traffic, nuisance and encroachment on the green belt. One parent felt that exposure to opencast had affected health, but no parents of children with asthma believed that childhood asthma was affected by dust from the opencast mine. Factors other than pollution, such as allergens, stress and damp weather were associated with exacerbation of asthma. The results suggest that anticipated health problems did not arise and the paper discusses reasons why concerns about health are often invoked when opencast mining is proposed.

INTRODUCTION

The perceptions of risk among communities exposed to environmental hazards, has received increasing attention in recent years. Empirical work has shown considerable differences between 'lay' and 'expert' groups in how environmental health risks are perceived and prioritised. Within the UK, the detailed study of risk perception among communities exposed to a potential environmental hazard has received little attention, particularly in semi-rural communities. However, community views are becoming increasingly important in relation to issues such as perceived health risk, siting of new industry and controversies between experts and lay people about 'acceptable risk'. Specifically, in relation to air pollution, recent studies have highlighted public concern and there has been discussion in terms of the wider public health debate.
This qualitative study explores how environmental health risks to children are perceived by parents and took place in tandem with an ongoing epidemiological study examining the association between exposure to dust from open cast coal mining and respiratory morbidity in children. The study had the following objectives:

1. To examine the perceptions of risks to health among parents whose children live in close proximity to opencast coalmining sites;
2. To characterise risk perceptions in parents whose children are asthmatic and non asthmatic; to use data about public perceptions prior to the publication of epidemiological findings to inform the research dissemination process.

SAMPLE
Four communities in North East England living in close proximity to opencast coal mining took part. 32 parents of children under the age of 11 years old (a sub-sample of a large random sample who took part in the linked epidemiological study) were interviewed on the following topics: views about the local area; children's health status; maintaining children's health; local environmental issues; perceptions of risk; the influence of knowledge about activity taking place at the open-cast coalmining site; how knowledge on health risks is obtained; whether risk perceptions relating to the open-cast mine lead to changes in planned activities e.g. keeping children indoors or away from school. Although one purpose of the study was to explore views on opencast coal mining, this was not explicitly stated to study participants.

All interviews were tape-recorded and transcribed. analysis was facilitated by NUD*IST software. Themes from the primary data were explored and emergent categories were placed within a more general analytical framework.

MAIN FINDINGS
The findings presented will focus on parental risk perceptions. Concerns about the possible impacts of opencast mining related predominantly to the effects on the landscape and pollution generated by excess dust:

"I imagine the reason why people are more against it is because it's like a blot on the landscape for a while"

"Well we have at the moment an opencast area which I must admit, when it first started and you left your windows open ... your window sills would be littered with dust. Dust that you wouldn't normally get on them."

However, not everyone was affected by dust:

"I haven't noticed an increase in dust which is something I thought I might have done"

Most parents were also concerned about the impact of extra traffic on what were often very small country roads:

"Another big issue with open cast is traffic. The wagons. Which is pollution as well. Damage to roads."
Most people had successfully campaigned to prevent large lorries going through their villages. Most people who were not immediately adjacent to the site felt that their distance did protect them from any immediate problems.

"A lot of people think the opencast is a problem, but I must admit, I don't feel we're close enough to it to notice any sort of dust or anything."

Each of the communities had been actively opposed to opencast sites, mainly on the grounds of the impact on the landscape, excess dust, noise and traffic. Health concerns were raised by only a minority. On the other hand, people recognised the potential economic benefits in terms of jobs although many respondents felt that few jobs were provided and disputed that they went to local people. However, once opencasting started, people's fears were not generally realised:

"There was an awful lot more concern about (the opencast) when it was being planned but actually since it's been there it's not really been that noticeable to be perfectly honest. Most of the traffic is diverted and doesn't come through the village and the worst you hear is the occasional boom now and again. It wasn't the plague we expected... there were various petitions and meetings and things at the community centre."

On environmental as well as health grounds concerns were anticipated and were not realised once the site was operational. This was particularly the case in relation to children's health. One parent believed that close proximity to an opencast site had affected her child's respiratory health:

"My son had more coughs and I certainly had more coughs. We both had bad chests. We both had coughs on a morning when we woke up and I took... I reckon I took my son more to the doctors in those first few years than I have done since and I had done before.

The majority of parents said that there was no effect on their child's health whatsoever, and there was no difference between parents of children with asthma compared to parents whose children did not have asthma. However, a small number of parents, whose children were not affected still believed that there might be a health effect:

"Just because it hasn't affected my child's asthma, doesn't mean it won't affect anothers. You don't know. As far as I'm concerned, that hasn't bothered us. But what's to say it isn't making little Johnny bad down the street? You don't know"

CONCLUSIONS
Opposition to opencast coalmining was largely founded on grounds of its environmental, rather than health impact. The majority of parents did not feel it had affected their children's health. However, their anticipated concerns were considerable. Most people believed that the lack of impact in their communities could be explained by distance from the site, topography, weather conditions and individual pre-disposition and did not feel that such a lack of impact would necessarily be replicated elsewhere. Such findings about the nature of anticipated concerns have implications for risk communication.
ACKNOWLEDGEMENTS
This study was funded by a grant from the Northern and Yorkshire NHS Executive, Research and Development Fund. Thanks are due to all the parents who took part in the study.

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ABSTRACT
The need to improve the processes of communicating about risks to public health has become well-recognised within the UK Department of Health (DH), and increasingly features in Government policy more generally. It has strongly influenced the design of the forthcoming Food Standards Agency and is prominent in other areas including the safety of medicines and the control of environmental hazards. Over the last three years, a concerted programme of work within DH has sought to raise awareness of the relevant issues and to improve practice. The programme has involved a number of interlocking elements: the present paper concentrates on the use of developmental workshops structured around hypothetical scenarios. These have been adapted and extended for use in settings beyond DH, particularly in the context of the new Food Standards Agency.

1. INTRODUCTION
This paper is based on a programme of work on risk based within the DH in London. We start with a brief overview of the programme as a whole (in which the first author has been involved throughout), before discussing one element involving all three authors – namely, the use of workshops to promote staff development. The programme drew on a recognition within DH not only that chronic mismatches between public and “expert” perceptions of risk existed, but that these should not be dismissed simply as the product of poor public understanding of the issues. Early on, three key principles were recognised:

- public reactions to risk can seem surprising, but are not totally unpredictable
- effective communication is necessarily a two-way process
- good risk communication requires a coherent strategy, rather than ad hoc reaction to events.

One strand in the programme has been to bring to bear substantive research on risk in an accessible form. For example, the volume of empirical studies on what factors provoke alarm suggests that there should be no need for policy-makers to be routinely surprised by public reactions to alleged risks. However, policy staff - let alone politicians- rarely have time to imbibe the academic literature. A second strand has been to promote attention to decision processes, both external (e.g. in engaging with key stakeholders with some clear overall rationale) and internal (e.g. by encouraging both scanning ahead and review of episodes as they occur). Given a tendency (Fischhoff, 1995) for organisations to repeat a series of steps in understanding risk communication issues – from the naïve “all we need do is to get the...
numbers right” to eventually recognising the need for partnership with relevant stakeholders - the programme aimed to make learning as rapid and permanent as possible.

To operationalise these ideas, the programme has had several linked elements in addition to the workshops described below. One has been production of guidance documents (Department of Health, 1997-8) summarising relevant research and its implications for the communication process. Within this, a two-page checklist provides a quick way of checking that key issues have been considered. Another strand has been a series of case study seminars, in which the handling of prominent past episodes and the current guidance are evaluated against each other. These link with other exercises, some cross-governmental (e.g. ILGRA, 1998). Finally, analysis of live issues has taken place in a decision support setting to help clarify objectives and options and devise appropriate contingency plans. About a dozen issues have been analysed to date. Alongside these internal activities, we have tried to foster constructive dialogue with both external stakeholders and academics (Bennett and Calman, 1999). Another part of the wider picture has been continuing reform of the processes through which Government uses expert scientific advice, introducing greater openness and transparency (OST, 1997; Coles, 1999).

2. THE DH WORKSHOPS

Within the overall scheme just outlined, an initial series of five workshops was designed specifically for DH staff (Bennett, French et al, 1999). The objectives were to identify key issues in relation to risk communication where the Department’s performance might be strengthened, to introduce and illustrate ways of structuring and analysing such issues, and thus to help DH staff deal more effectively with risk issues in their own policy areas.

The format was highly interactive, to build on participants’ existing skills and experience. Following a half-day pilot event, each workshop lasted a full day. Each was built around a different hypothetical scenario, an example being summarised in Box 1. Three involved genuine risks to public health, while two turned out to be "scares". Participants received “Phase 1” just prior to the event, and the scenario then unfolded during the day. Each workshop mixed plenary discussions, presentations from the facilitators and breakout group work. Topics introduced included:

- research on how individuals react to uncertainty, with emphasis on the thinking processes that can lead to error and bias on the part of experts and public alike
- the social context of risk as reflected in Cultural Theory and Social Amplification Theory, emphasising the importance of trust.
- value-focused thinking (Keeney, 1992) as a way of ensuring that aims are always kept to the fore
- simple methods for identifying and classifying key stakeholders and uncertainties, and monitoring how these may change over time.
- the concept of robustness (Rosenhead, 1978) and the qualitative use of decision trees, both opening up discussion of the need to think contingently.
The events were evaluated through both questionnaires and informal feedback, and received enthusiastic responses. Learning was very much two-way, with the external facilitators gaining a greater appreciation of the complexities and multiple pressures bearing on policy-making in this context. Of the key issues to emerge, three have particular relevance to organisational (rather than just individual) practice:

**Setting of objectives** Participants in the early workshops rarely discussed objectives before considering possible actions. Consequent failure to recognise differences between presumed aims was identified as a potential risk. This highlighted the importance of having explicit objectives in tackling specific cases, clearly linked to overall organisational aims.

**Organisational learning** From discussion, it was clear that there was often little review of each risk episode. Due to pressures on time, staff more typically moved straight on to dealing with the next issue. The resulting lack of "corporate memory" limited opportunities for learning and improvement.

**The use of process expertise** Generally there was little recognition of the distinction between "process" and "content" expertise. Experience with decision analysis and risk management elsewhere suggests the value of recognising specific "process" activities such as facilitation or problem-structuring.

3. **FURTHER DEVELOPMENTS**

The final workshop in the first series was expanded into a Cross-Departmental event, with participants from several different arms of Government. Response to this confirmed wider interest in such events, and a variant on the design is now offered across Government under the aegis of the Civil Service College, with input from the original facilitators.

Another series of events has been developed in the run-up to the Food Standards Agency (FSA), shortly to be established as a new body with responsibility for food safety, and with a specific risk communication function. The FSA stems directly from a perceived loss of public confidence in existing arrangements, and in particular the difficulty of combining two distinct functions – promotion of the industry and protection of the consumer – within the Ministry of Agriculture, Fisheries and Food (MAFF). While FSA will largely be staffed by former MAFF and DH personnel, there are several departures from previous practice. In particular, the Agency will have an independent Chair and Council, and will be able to publish its advice to Ministers. The need for a substantially new way of working has been recognised by the combined MAFF/DH body already set up in advance of the FSA’s formal inauguration, known as the Joint Food Safety and Standards Group (JFSSG). In this context, the existing workshop design has been adapted to serve in three modes:

- A further series of events has been run to promote JFSSG staff development, with MAFF and DH staff working together on scenarios. The previous design has been adapted to include more input on the “media” component, provided by a practising journalist and involving use of role-play interviews. (These are also to be added to the general Civil Service workshops, which are to be expanded to a day and a half.)

- Events for senior JFSSG staff are to be run to test out working relationships between FSA, DH, MAFF and with other public bodies. Proposed procedures for dealing with risk episodes will be tested against both past cases and hypothetical scenarios.
An extended event will involve participation by representatives of external stakeholders (including consumer, producer, retail and other organisations) in reacting to a scenario. It is hoped that this will be the precursor to a series of “multi-stakeholder” events.

4. FINAL COMMENTS
Within this brief paper, we hope to have demonstrated a serious commitment to improved risk communication on the part of DH and the forthcoming FSA. That is not to claim that all problems have been solved. Difficult cases will no doubt continue to occur, and public trust cannot be earned overnight. No organisation always follows its own understanding of best practice, particularly under time pressure. Nevertheless, appreciation of the key issues raised in the risk literature has undoubtedly grown. In more recent workshops, it has been clear that participants start from a higher baseline awareness of “process” issues (especially the importance of objectives and the desirability of review). More specifically, responses to the workshops suggest that a modest expenditure of resources can have a significant effect – provided that the organisational culture is moving in a favourable direction.

REFERENCES


Box 1: Synopsis of Scenario: *E. coli* and German sausages

(Phase 1) A number of cases of *E. coli* food poisoning are reported across the UK. No obvious connection is identified. In general, media attention is focused elsewhere, but the *Today* programme has run the story, asking if British food hygiene was in crisis. The report also retold the histories of other recent outbreaks, issues surrounding hygiene in abattoirs etc. DH has issued a statement that officials are working hard to identify the sources of the outbreak; there is no evidence yet for a common cause; that it was too early to speculate on any wider implications and that all those suffering are receiving the best possible care.

There is a need to issue a further statement. The only new factual information known is that several cases attended the same golden wedding celebration.

(Subsequent phases) More cases are reported and two deaths occur. The source of infection is found to be German pfeffersalami from a supermarket. The chain has a national delicatessen packing centre, and a large batch of salami wrapped there two weeks before is implicated in the food poisoning. The supermarket removes all delicatessen products from its shelves. It is not clear where contamination entered the system. Hygiene at the centre appears to be excellent. Alternatively the batch of salami could have been contaminated on import: the supermarket is the sole UK importer from the German manufacturer.

Subsequently, the outbreak dies down. No proof emerges as to the source of infection. Both the packaging centre and the manufacturer have high standards. Nevertheless, the media carry articles implying that German hygiene was at fault. The German Government "gently" voices a concern that this reaction is retaliation for Germany's stance on BSE. Meanwhile MAFF and the Cabinet Office are anxious not to be "bounced" into further decisions on the role of the proposed Food Safety Agency.

*A press release is required. What should be its main elements? What else should be communicated, and to whom?*
IMPLEMENTING THE SEVESO II DIRECTIVE IN SWEDEN

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ABSTRACT
With the membership to the European Union, a number of new European directives have to be implemented in Sweden. One of these is the Seveso II Directive, dealing with industries having to communicate risks related to their production, and what the public should do in case of an emergency to the public. In Sweden, the new directive states that the industries are responsible for providing this information, but the municipality is responsible for distributing this information to the public. There are about 70 Seveso I classed industries in Sweden today.

The aim of this study, initiated by the Swedish Emergency Rescue Service, was to investigate the public’s knowledge of risks and emergency preparedness, and also to study the cooperation between the local authorities and the industry. Two municipalities have been chosen to participate in this pilot study, with the addition of one municipality serving as a control. A total of 1,508 randomly picked subjects from the three municipalities received a questionnaire containing 24 items concerning risks related to chemical industries and 8 additional background questions. In a second questionnaire, the respondents from this first study will be asked to answer similar questions, but with a focus this time on an information campaign that will have been undertaken by the local authorities, after the distribution of the initial questionnaire. During the planning and implementation of the Seveso II Directive, we have documented the processes surrounding the cooperation between industries and the local municipal authorities. In this contribution, we will discuss our evaluation so far and present preliminary results. The focus of our study is three-fold: to study the public’s knowledge and attitudes towards chemical risks in their community, the public’s knowledge of emergency related behavior, and the trust and credibility of those authorities involved in the implementation of the directive. Preliminary results indicate that the respondents have a positive attitude towards the local chemical industry.

IMPLEMENTING THE SEVESO II DIRECTIVE IN SWEDEN

BACKGROUND
Since Sweden joined the EU in 1995, a number of new laws and regulations have had to be adapted to comply with the regulations of the European Union. One of these is the Seveso II Directive, which has been a law in Sweden since July 1st 1999. The law deals with the safety and information responsibilities of industry handling chemicals that are hazardous to individuals and to the environment.

There were already laws in Sweden before the implementation of the Directive that require industries handling large amounts of hazardous chemicals to provide safety reports, such as a risk analysis of a worst-case scenario, to the authorities involved (Storskalig Kemikaliehantering). What is new in Sweden following the implementation of the Directive, is the information that the industries have to provide to the public. There was also an increase in the number of Seveso-type facilities, compared to the older classification of these types of...
industries handling large amounts of hazardous chemicals. Before the Directive there were about 70 facilities that fell under the old classification, with the implementation of the Directive the number increased to about 2000. The Directive states that information must be distributed to ‘the public concerned’, regarding what types of chemicals are present at the facility, the nature of these chemicals (how they are hazardous to the public and the environment), the dangers with production, emergency procedure and what the public should do in case of an emergency. The law states that the industry is responsible for providing this information, including covering the costs for this, to the local authorities (municipalities) that are responsible for distributing this information to the public.

AIM AND DESIGN OF THE STUDY
The present study was a pilot study, aimed at investigating two municipalities involved with implementing the Seveso II Directive. Two municipalities with similar industries took part in this study. The companies were both subsidiaries of a large chemical company, and both handled large amounts of ammonia. The two communities were also similar with regards to the population, where both had about 20,000 inhabitants in their municipality. A third municipality where no information campaign encouraged by the Swedish Rescue Services Agency would take place was used as a control group.

There were two purposes of this study: 1) to evaluate the cooperation between the industry and the local authorities. 2) to measure the public’s knowledge of and attitudes towards chemicals and the risks they might pose, and also to measure the knowledge of emergency related behavior, both before and after the information has been distributed to them. This study will therefore be completed in two parts, with only one part reported here. This part of the study took place before the information had been completed and distributed.

The design of the study was to attend and observe the meetings between representatives from the municipality and the industry to study their cooperation. It was hoped that this might help in identifying possible problems or issues that were unclear, in order to provide guidelines to other local industries and authorities having to work together.

The second part of the study was to measure the public’s knowledge and attitude towards risks rising from chemicals and chemical industries. In April of 1999, a survey went out to 500 people in the three communities (1,508 total). This questionnaire was based in part on one used by Jungermann (Jungermann et al., 1996). It measured the general attitude towards risk, attitudes towards chemical industries, knowledge about emergency behavior and also asked about the credibility of different sources of information. The questionnaire had a total of 24 items and 8 additional background questions.

RESULTS
The cooperation between the local authorities and the industry was nothing new for the two participating communities. In accordance with the old Swedish law, they have worked together before and there seemed to be no apparent problems or issues that had to be resolved in this study. A problem that might surface, is when different industries have to work together with one local authority and have to divide the costs amongst themselves. Since the Seveso II Directive does not distinguish between large and small industries, carrying the cost for the information might affect different companies in many different ways. Since in many cases there has been an earlier cooperation between the industry and the authorities, the division between whom does what on paper might not be so obvious in reality. The industries might
see this as a good chance to promote their business and to create better ties to the community around them (increase their social capital).

In this contribution, material concerning the cooperation between authorities and industry has not been subjected to closer analysis and will therefore not be included in this contribution.

The results of the postal survey reported below are based on questions concerning the image and attitude towards the local chemical industries. Other results from this study dealing with general risk perception, credibility of different authorities and emergency related behavior, have been omitted from the paper, for reasons of limited time and space.

A total of 759 (out of 1,508) people responded to the survey, giving a response rate of 50,3%. The sample consisted of 381 (50,1%) men and 378 (49,5%) women. 70,8% of the sample were married and 38,9 % of the total sample had children.

The subjects were asked a number of questions pertaining to the local chemical industries. We asked them if they knew of any local chemical industries and if they had knowledge of the activities in these facilities. They were also presented with questions regarding whether they thought these activities presented a potential risk, and how they would estimate their knowledge of these risks, to both their health and to the environment, both during normal production and in case of an accident. There were also questions concerning the quality of the information available to them concerning emergency behavior and how they estimated the credibility of information provided to them in case of an emergency.

A total of 81,4% of the sample said they knew of (that there were local chemical industries) local industries, either through their “profession” (10,6%), “education and profession” (9,4%) or through “someone else” (15,6%).

43,1% of the sample thought they had “some” knowledge of the activities in the local chemical industry, whereas 48,4% said they had “no” knowledge of this.

60,2% reported that the local industry “did not” pose a threat to their health during normal production. However, would there be an accident in the facility, 88,2% though the local industry “would” pose a threat to their health.

When asked to estimate their knowledge of what risks an accident would pose to them, 5,9% reported having “great” knowledge, 49,4% said they had “some” knowledge and 41,7% said they had “no” knowledge of the risks.

The effect on health in case of an accident was estimated to have a “great” impact by 43,5% and to have “some” impact by 33,8% of the sample.

In response to questions regarding the impact an accident would have on the environment, 51,2% thought it would be “great”, and 31,2% thought there would be ”some” impact.

Questions about the quality and credibility of the information they had available to them concerning the risks with production and how to respond in case of an accident showed that 38,1% of the respondents found the information “predominantly” credible, 32% found it credible to “some extent” and 24,9% did not know of any such information.

Roughly half the sample (50,9%) estimated that the information provided to them in case of an emergency would be “fairly good”, and 15,7% estimated it to be “very good”.
We also asked them whether they thought that accidents did occur at the local industries that are not reported or brought to the authorities knowledge. 47.1% thought that it did, 18.7% though it did not and 33% did not know. Also, the respondents were asked to state if they had confidence in that the local industry was concerned about the health and safety of those who live in close proximity of the facility. 20.4% of the respondents reported having “great” confidence, 53.7% have “some” confidence and 9.3% had “none” (14.6% did not know).

It might be worth mentioning that in the first stage of analysis, significant differences between men and women have been found. These are consistent with other findings and show that men tend to have a lower risk perception than women.

CONCLUSIONS
These findings seem to indicate that the confidence in and image of the local chemical industries is predominantly good. One of the important aspects of this survey is that it has provided a pool of respondents that can be provided with the second questionnaire. Since the purpose of this study is to investigate if publics’ attitudes and knowledge is effected by an information campaign, it is vital to have access to a group that can be followed through this process.

ACKNOWLEDGEMENTS
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REFERENCES
THE POPULATION AND SPECIALISTS ATTITUDE TO THE ATOMIC ENERGY IN RUSSIA

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ABSTRACT
The questioning study was carried out on habitants of territories, contaminated and non-contaminated after Chernobyl Accident (1993-1995), and specialists working in atomic energy and radioactive waste management, students and school teachers (1998-1999). In spite of the common assessment of Chernobyl Accident like national calamity the most of respondents believe in the necessity of nuclear power stations right now. 52% of responded specialists supported the idea of it in future, but students and school teachers didn’t support it.

The main purpose of the study was to investigate some aspects of subjective assessment of radiation danger and the attitude to nuclear energy by various group of population in Russia.

METHODS
The questioning study [1] involved the following groups of respondents: “professionals” – the people working in the field of nuclear energy; school teachers of ecology in St.Petersburg (big industrial town); students-ecologists of the first grade in St.Petersburg and Murmansk (small town in Cola Peninsula). Population considers the professionals and the school-teachers as the objective sources of information and trusts them. The students of the first grade of University are the part of population “in total” and, at the same time, they are part of the young population with special interest to ecology.

<table>
<thead>
<tr>
<th>N</th>
<th>Respondent’s groups</th>
<th>Number of respondents</th>
<th>Respondent’s age</th>
<th>Year of investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Professionals</td>
<td>54</td>
<td>29 – 60</td>
<td>1998</td>
</tr>
<tr>
<td>2</td>
<td>School teachers, St.Pb.</td>
<td>63</td>
<td>23 – 42</td>
<td>1999</td>
</tr>
<tr>
<td>3</td>
<td>Students-ecologists, St.Pb.</td>
<td>103</td>
<td>17 – 20</td>
<td>1999</td>
</tr>
<tr>
<td>4</td>
<td>Students-ecologists, Murmansk</td>
<td>142</td>
<td>17 – 20</td>
<td>1999</td>
</tr>
<tr>
<td>5</td>
<td>Population on contaminated areas</td>
<td>250</td>
<td>18 – 70</td>
<td>1993</td>
</tr>
<tr>
<td>6</td>
<td>Relocated population</td>
<td>250</td>
<td>18 – 70</td>
<td>1995</td>
</tr>
<tr>
<td>7</td>
<td>Population on clean areas</td>
<td>246</td>
<td>18 – 70</td>
<td>1993</td>
</tr>
</tbody>
</table>

Some results were compared with the data of JSP-2 investigation [2] which covered the questioning of all ages population living in areas contaminated after Chernobyl accident in clean areas and the replaced people (Table 1).
1. Assessment of various danger factors. There were 18 factors of risk including social, economical, political, environmental factors [3] in 1998-99. The first 1-5 places in the list have been occupied with social factors (crime of violence, low level of medical service, economic difficulties and so on) for all of respondents groups. The last 8 places have been occupied with habitual, usual everyday harmful factors as smoking, alcohol, everyday life trauma and so on for all groups. Radiation like harmful factor have been placed by the specialists at the 11-th place; by school teachers – at the 8-th place; by the St.Petersburg students – at the 9-10-th places, dividing these places with AID. The radiation was rated by Murmansk students at the 5-6 places, dividing these places with economical difficulties. The last result was rather unexpected. Cola Peninsula is one of the clean area in Russia till right now. The local authorities and mass-media try not to disturb population with possible radiation contamination connected with Nuclear Installation of North Fleet. There are only International Organisations which tried to attract the public attention to this problem. Their attempts seems to be successful, at least – for students – future ecologists.

2. Radiation danger for various personalities. More detailed information characterizing attitude of respondents towards radiation danger for various personalities (Table 2) has been shown the highest marks of all groups of respondents for the health of the population of our country. The marks were less rather for health of respondent's children and minimal marks were for own health. The estimation of radiation danger for own, his children and population health is higher in St.Petersburg then in Murmansk. It is in contradiction with high marks of radiation danger by Murmansk students (see above). Specialists have had the minimal level of assessment for health of all groups of personalities. The school teachers estimations of radiation danger for their children were highest for all groups, including the population at contaminated areas.

<table>
<thead>
<tr>
<th>Radiation danger for:</th>
<th>Groups of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Myself</td>
<td>2.79</td>
</tr>
<tr>
<td>My children</td>
<td>2.88</td>
</tr>
<tr>
<td>Population of our country</td>
<td>3.10</td>
</tr>
<tr>
<td>Myself and my family</td>
<td>-</td>
</tr>
</tbody>
</table>

3. The attitude towards the nuclear energy. The opinion of respondents about future energetic sources (Table 3) are different for specialists, who have chosen the nuclear power stations as main energetic source more then in a half and nonspecialists, who have preferred the hydroelectrical station. Only 10% of them have chosen the nuclear energetic sources. Evidently this judgment is closely connected with opinion of safety such installations. The data of Table 4 confirm it: more then 50% of specialists agreed to live in the neighborhood of nuclear industry enterprises and less then 10% of other groups of respondents did it.
Table 3. Choosing of the main type of energy for nearest future. (% of the respondents)

<table>
<thead>
<tr>
<th>N N of the groups</th>
<th>Cool</th>
<th>Gas</th>
<th>Oil</th>
<th>Water</th>
<th>Nuclear fuel</th>
<th>I don't care of it</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>16.7</td>
<td>0</td>
<td>2.2</td>
<td>51.8</td>
<td>7.4</td>
</tr>
<tr>
<td>2</td>
<td>1.6</td>
<td>12.9</td>
<td>0</td>
<td>59.7</td>
<td>11.3</td>
<td>6.5</td>
</tr>
<tr>
<td>3</td>
<td>4.9</td>
<td>3.9</td>
<td>3.9</td>
<td>68.9</td>
<td>11.7</td>
<td>3.9</td>
</tr>
<tr>
<td>4</td>
<td>2.1</td>
<td>10.7</td>
<td>0</td>
<td>73.6</td>
<td>8.6</td>
<td>4.3</td>
</tr>
</tbody>
</table>

So, almost all of respondents from population and 37% of questioned specialists did not agree to live with atomic industry enterprise in the neighbourhood in spite of many promised advantages for the habitants these areas.

Table 4. Attitude to the atomic industry enterprises in the neighborhood. (% of the respondents)

<table>
<thead>
<tr>
<th>N N of the groups</th>
<th>Agree</th>
<th>Not agree</th>
<th>Hardly to reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Specialists</td>
<td>57.4</td>
<td>37.0</td>
<td>5.6</td>
</tr>
<tr>
<td>2. School teachers</td>
<td>6.5</td>
<td>74.2</td>
<td>16.1</td>
</tr>
<tr>
<td>3. Students, St.Pb</td>
<td>5.8</td>
<td>74.8</td>
<td>19.4</td>
</tr>
<tr>
<td>4. Students, Murmansk</td>
<td>5.7</td>
<td>82.9</td>
<td>10.0</td>
</tr>
</tbody>
</table>

The attention of population from various areas towards NPS's is very positive in spite of Chernobyl accident (Table 5). The most respondents from all areas in three countries did not agree to close all NPS's and hoped to have more safe NPS's in future.

Table 5. Population's attitude to the nuclear power stations (% of the respondents)

<table>
<thead>
<tr>
<th>N N of the groups</th>
<th>Answer</th>
<th>Russia</th>
<th>Belarus</th>
<th>Ukrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Contaminated area</td>
<td>To close the Chernobyl NPS</td>
<td>77.0</td>
<td>90.6</td>
<td>80.0</td>
</tr>
<tr>
<td></td>
<td>To close all the NPS</td>
<td>32.0</td>
<td>44.4</td>
<td>38.0</td>
</tr>
<tr>
<td></td>
<td>To build more safe NPS</td>
<td>93.4</td>
<td>95.0</td>
<td>92.0</td>
</tr>
<tr>
<td>6. Relocated</td>
<td>To close the Chernobyl NPS</td>
<td>85.9</td>
<td>91.7</td>
<td>81.0</td>
</tr>
<tr>
<td></td>
<td>To close all the NPS</td>
<td>47.9</td>
<td>49.3</td>
<td>48.0</td>
</tr>
<tr>
<td></td>
<td>To build more safe NPS</td>
<td>92.3</td>
<td>96.4</td>
<td>88.0</td>
</tr>
<tr>
<td>7. Clean area</td>
<td>To close the Chernobyl NPS</td>
<td>72.7</td>
<td>78.0</td>
<td>75.0</td>
</tr>
<tr>
<td></td>
<td>To close all NPS</td>
<td>41.2</td>
<td>34.1</td>
<td>39.0</td>
</tr>
<tr>
<td></td>
<td>To build more safe NPS</td>
<td>92.7</td>
<td>97.2</td>
<td>91.0</td>
</tr>
</tbody>
</table>

Appraisal of radiation and radio-ecological knowledge by specialists. Specialists (80%) considered their knowledge sufficient. As usual self-appraisal of women is more modest – only 60 % of women considered their knowledge as sufficient. What have drawn attention is that 20 % of specialists (including 40 % of women) suppose their knowledge insufficient. One respondent was completely ignorant in the issues, and one found it difficult to reply. This conform to objective evaluation of their knowledge – from 15 to 30 % of questioned could not
give the right answer to the question about methods of detection ionizing radiation and doses of irradiation of people. More, then 75% of population and 20% of specialists would like to know about radiation much more then they know now.

Specialist’s proposals in radiation protection (open-ended question). Only 26 % of questioned specialists stated their opinion. Altogether there were 23 proposals from 14 persons. Tree of them were of the character of general statements, evidently, addressed to authorities, of the necessity first of all to take care of the good of humane, and of the necessity to elaborate the balanced programs of the future development.

Of all 23 proposals 13, that is more than half, were referred to issues of correct professional information on radiation for population and of the necessity of special teaching this theme. It is relevant to any level of education beginning from the school and ending with the higher education for journalists, politicians and persons, making decisions.

Short conclusion.
The more quiet attitude to the nuclear power stations and nuclear enterprises have been demonstrated by the professionals and by the population at all, including the population at the contaminated area.
The Murmansk students-ecologists estimated ecological, especially radiological situation in their living place like more dangerous then the others. St.Petersburg school teachers of ecology estimated the possible influence of radiation to their children health higher, then the others. Evidently the higher danger estimates of the teachers were caused with the fact that all of them are women and have had the children.

In 1999-98 year the major part of respondents (students and teachers) absolutely did not believe in possibility of ensuring save living conditions for population in neighbourhood of working atomic industry enterprise.
The real need exists of increase of level of radiation-hygiene and radio-ecological knowledge for all the population but also for the specialists.

BIBLIOGRAPHY
### Table 1: Attitudes in the Family, Industry, and Enterprise in the Real Estate Industry Among 1,000 Respondents

<table>
<thead>
<tr>
<th>Category</th>
<th>Agree</th>
<th>Disagree</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family</td>
<td>67%</td>
<td>28%</td>
<td>5%</td>
</tr>
<tr>
<td>Industry</td>
<td>73%</td>
<td>22%</td>
<td>5%</td>
</tr>
<tr>
<td>Enterprise</td>
<td>78%</td>
<td>18%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Note: Percentages are rounded to the nearest whole number.

Agreement of attitudes is based on respondents' self-assessment of their knowledge in each category. A total of 1,000 respondents were surveyed. The categories include family, industry, and enterprise. Respondents were asked to rate their level of agreement on a scale of 1 to 5, with 1 being strongly disagree and 5 being strongly agree. The table above shows the distribution of responses for each category.
RADIO-FREQUENCY FIELDS AND CELULAR TELEPHONES: THE CANADIAN CASE IN A CURRENT INTERNATIONAL RISK CONTROVERSY IN WIRELESS TELECOMMUNICATIONS

W. Lyon & G. Pfeil

SESSION 6

RISK COMMUNICATION - APPLICATIONS
RADIO-FREQUENCY FIELDS AND CELLULAR TELEPHONES:
THE CANADIAN CASE IN A CURRENT INTERNATIONAL RISK
CONTROVERSY IN WIRELESS TELECOMMUNICATIONS

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Installations for four of the new digital telecommunications networks for personal communications services (PCS) began in Canada in 1997. These networks utilize the 2GHz part of the spectrum, whereas the older cellular telephone technologies use frequencies in the 800-900 MHz range. One significant feature of these new networks is that they require numerous roof-top antenna installations. In Canada one federal department, Industry Canada, issues licenses for transmitter and antenna installations, while another, Health Canada, is responsible for the health and safety (risk) regulations, which are published as "Safety Code 6" (issued 1990). Safety Code 6 specifies exposure limits for workers and citizens and covers frequencies ranging from 10kHz to 300 GHz.

In the Summer of 1997 some citizens in Vancouver, British Columbia became aware of the new installations when their community was informed that a local school had been asked to allow the placing of a roof-top antenna on its building. Shortly thereafter, the citizens discovered that another antenna had already been installed inside the steeple of a nearby church; the church hosts a day-care centre in its facilities. Concerns about health risks were raised, public meetings (including meetings with representatives of the two federal departments) have been held, and the controversy has been simmering in different parts of Canada ever since.

An important part of subsequent events was that the citizens did not think that the information provided to them by government and industry was complete, nor responsive to their specific concerns. Some of them then turned to the Internet for information and self-education in health risk issues of concern to them. We examined these resources, and this paper describes the results of a detailed search of the Internet on hypothesized human health effects of radio-frequency electromagnetic fields. A conceptual map was developed which captures linkages between concepts according to their proximity and interconnectedness in the Internet milieu. A key issue is the abundance of summaries of scientific information provided in lay terms by non-institutional sources. These summaries tend to include very frank discussions of key concerns in scientific and regulatory inference and frequent reference to the rationality of the burden of proof applied in science where public health protection is concerned.

Individual members of the public who have concerns about risk issues have begun using these Internet resources to gather information, establish contact with like-minded people
everywhere on the globe, obtain guidance on how to ask questions of experts, and prepare themselves to become skilled intervenors in risk controversies. The resources available to them on the Web include complete copies of many peer-reviewed scientific publications and other documentary material from excellent sources. The information-search, documentary retrieval, and networking facilities of the Internet have huge advantages over earlier resources available to the general public, advantages that will grow steadily in future years. Among other things, citizens have become aware of intense controversies within parts of the scientific community over the evaluation of the health risks associated with these technologies.

There are some corresponding disadvantages in using Internet resources as well. Many sites are maintained by activists who are committed to a particular perspective on issues and who also have (judging by the contents) reasonably good scientific training; individuals visiting these sites who are non-experts in these matters can end up just with a wider array of opinion on what the scientific issues are, without any way of evaluating the relative merits of what they find. Second, much (but by no means all) Internet activism has the tenor of “guerrilla warfare” and conspiracy, a crusade against the large institutional players in government and industry, which influences the presentation of material. Third, straightforward scientific reports are mixed liberally with anecdotal evidence; casual visitors to their sites need to exercise some caution in sorting through what they find.

These and other weaknesses are serious matters, but on the whole they do not cancel out the offsetting advantages. In any case the Internet as a public information resource is here to stay. Citizens concerned about health and environmental risk issues will derive greater benefit from Internet resources over time as more players set up shop there—including those who have a mission to deliver balanced, disinterested, up-to-date, and credible accounts of ongoing risk controversies.

The radio-frequency fields controversy in Canada is a perfect case study in the existence of a risk information vacuum and its consequences for risk management. This can be seen clearly once the elements presented earlier are arrayed systematically. In summary, there is clear evidence that governments had authorized private industry (in return for financial considerations) to introduce a new technology across Canada, including numerous installations at sensitive locations within communities, without first having in place a clear and credible explanation of the associated risk factors. This is in our opinion undeniably a dereliction of duty for governments, which have the primary responsibility for managing risks. From a practical standpoint it is also asking for trouble. One hopes that both industry and governments have learned something from this venture.
RISK ANALYSIS AND COMMUNICATION
FOR A DISPOSAL SITE OF RADIOACTIVE SLUDGES:
AN EFFICIENT STRATEGY

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ABSTRACT
Remediation of the decommissioned Uranium mining and milling facilities in Eastern Germany, carried out by the state-owned company WISMUT, requires the extensive use of quantitative risk analysis and decision making tools. A peculiarity is the long time horizon of some 100 up to about 1000 years to be covered by the environmental and health risk analysis. Apart from the purely numerical risk and cost figures, the permitting procedure for each single project depends also sensitively on the way how these risk figures are presented and communicated to authorities and the public. The time required to obtain a permit has become a crucial factor to reduce costs. Therefore, an efficient strategy to ease the permitting procedure was strongly requested by WISMUT.

Our paper demonstrates how classical quantitative risk analysis is integrated into a two-step strategy of risk communication between WISMUT, authorities and the public. The first step is a thorough and credible quantitative risk analysis which confirms, in most cases, the ranking of options with respect to their long-term risk (and associated costs) as perceived by authorities and the public. This "reassurance step" creates common ground for understanding the issue by all parties involved. In the second step, the risks of each option are discussed and compared to risks at other WISMUT sites or everyday hazards ("benchmarking"). It is just this combination of a transparent, thorough and credible quantitative analysis of environmental and health risks and their realistic comparison to other hazards which greatly accelerates permitting procedures, provided the risks involved are actually small but attract great public concern (as is often the case).

As an example, the siting of a disposal facility for 40,000 m³ solidified radioactive and toxic mine water treatment sludges is considered. Applying our two-step strategy, regulatory approval was obtained within unexpectedly short time.

INTRODUCTION
In Western Saxony and Eastern Thuringia, a total of 220,000 tons of Uranium were produced by the Soviet-German company SDAG Wismut during the years from 1946 to 1990. Mining and milling activities had caused considerable environmental damage and health risks which prompted public and regulatory concern. Since 1991, extensive rehabilitation and remediation tasks are carried out by the state-owned company WISMUT GmbH [1]. Since the majority of
remediation projects affect radiation protection issues, the application and permitting procedure is more involved and require a more complex communication between WISMUT and permitting authorities in different fields. On the other hand, the time needed to obtain a permit for any remediation action is of paramount importance. All activities are closely linked and interlaced, and resources must be allocated with minimum idle time.

Of the tasks that require a large portion of the resources available for the WISMUT project, water management and treatment is of central importance. Mine effluents and seepage waters from tailings ponds and waste rock piles cannot be discharged without treatment, due to their high concentrations of radionuclides (Uranium, Radium) and toxic and heavy metals such as Arsenic. This prompts the need for water treatment plants. Apart from the water treatment plant itself it is the sludge disposal which attracts considerable regulatory attention and public concern. The sludges contain, in concentrated form, all those contaminants that have been removed from the water. Table 1 provides a rough picture of typical sludges.

### Table 1 Typical composition of the sludge from the Schlema-Alberoda mine water treatment facility, as % of dry matter

<table>
<thead>
<tr>
<th>Radionuclides</th>
<th>Non-radioactive components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium 3%</td>
<td>Arsenic 4%</td>
</tr>
<tr>
<td>Radium 35 Bq/g</td>
<td>Iron 14%, Manganese 10%</td>
</tr>
<tr>
<td>Amidoxime (as sorbent for Uranium) 16%</td>
<td></td>
</tr>
</tbody>
</table>

The sludges are solidified by portland cement, resulting in blocks of 1x1x1 m³. Approximately 40,000 m³ of those blocks must be disposed at an appropriate site.

The location of the disposal site is a central issue in the application and permission procedure. Apart from general requirements such as geotechnical stability and radiation protection during handling and disposal, an extensive catalogue of criteria is applied to identify the preferred option. They include but are not restricted to costs, means of transportation available and the number of affected population, anticipated regulatory and public acceptance, impact on environmental goods (ground and surface water), robustness against inadvertent human intrusion, long-term stability (hydraulic, geochemical), and conflicts with other remediation activities of WISMUT.

Site options are evaluated by WISMUT with respect to these criteria by a Multi-Attribute Utility Analysis (MAUA) or, if warranted, by simpler methods. Sensitivity analyses are always carried out to demonstrate the stability of the preferred option. Practically, only a small number of criteria (notably costs) do actually influence the final decision. This procedure is now widely accepted by all parties involved (WISMUT, regulators, public). For the disposal of the sludges from the Schlema-Alberoda mine water treatment facility (MWTF), two options had to be compared in the final stage of the permission procedure, after a larger number of suboptimal options had already been excluded:

(A) disposal in a specifically prepared cell on a waste rock pile (waste rock pile H 371/1) which is close to the MWTF,

(B) subterranean storage in a decommissioned mine above flooding water table (Pöhla mine) which requires transportation of the wastes over nearly 30 km.

MAUA clearly showed that the Pöhla mine option would be dominated by the H 371/1 option. Extensive sensitivity analyses and common sense supported this picture. However, since MAUA lumps a wide range of quantitative and qualitative criteria into a single utility
measure, it may provoke objections whether the essential aspects (such as the long-term release of contaminants from the disposal cell) would have received due consideration. In order to obtain the permit, an in-depth risk analysis and communication project was launched with the following objectives:

- to probabilistically estimate the long-term release of contaminants from both sites,
- to review the ranking of the options and communicate the results among all parties.

An efficient risk communication strategy was essential to minimize further delays of the permitting procedure. A two-step strategy was developed which lead to unexpectedly quick issue of the approval for the H 371/1 option.

**Step 1: Quantitative Risk Analysis: "Reassurance"**

In a first step, an estimate of the long-term release of contaminants from both disposal sites was derived. The objectives of the first step were

1. to provide a common ground of understanding for all parties involved,
2. to create confidence in the scientific soundness of the analyses and arguments set forth.

A probabilistic approach was chosen as the most appropriate tool for analysing the multi-barrier system's behaviour in the far future. Simulating a wide variety of failure scenarios, those barriers were identified which have the most significant impact on the infiltration rate. Each of the relevant barriers were then assigned a mean lifetime which was translated into failure probabilities by a geometric probability distribution. Active institutional control (AIC) was assigned an average time of stability before it collapses. In turn, it can also be reinstalled after collapsing within an average time. Repair works on the cover system are allowed provided the seepage concentration and the infiltration rate are above given tolerance levels and the AIC exists. The uranium concentrations of the seepage water (i.e., after it had come into contact with the solidified wastes) were assigned an empirical resampling distribution. The simulation results for the uranium release in the base-case scenario are shown in Figure 1.

![Figure 1 Time-dependent release of Uranium from the H 371/1 disposal site](image)

The probabilistic model was then distributed among all involved parties for "number experiments". Since commercially available probabilistic spreadsheet tools would have provoked licensing problems, a probabilistic PC tool was custom-made by one of us (CK) which allows the user to change all relevant parameters and to run his/her own simulations. A user manual was provided to make sure that the model is readily understood by everybody.

The most important results of this step were that

- the annual amount of uranium which will be released from the H371/1 disposal cell is in the range of some tens of grams.
the systems analysis confirmed what was seen as a main argument by the authorities to favor the Pöhla mine option: the H371/1 site releases by a factor of about 100 more uranium than the mine option which can prevent the wastes from water intrusion,

all parties were given the confidence that the basis for the subsequent comparison of both options was scientifically sound, credible, transparent and reproducible.

**Step 2: Comparison of Risks by Realistic Scenarios: Benchmarking**

A conclusion had now to be drawn as to which site option would be preferable. Only after creating confidence in the first step is was possible to set forth the following arguments without facing reservations:

- the uranium released from the H371/1 site leads to negligible doses and health risks,
- the release would not be measurable in the waste rock seepage water at all,
- there are no long-term health risks associated with the H371/1 disposal option,
- but: there are strong interferences with other WISMUT remediation activities which may lead to severe delays and additional costs to be borne by the taxpayer
- at least 5 villages and towns would be affected by the transports to the Pöhla mine,
- conventional risks (e.g., from transportation) would eventually dominate the total risks,
- transferring radioactive wastes from one town to another would be felt unfair by those receiving them.

All arguments were readily accepted by the authorities and the permit was issued immediately after their presentation by B.P.S. Engineering and WISMUT.

**LESSONS LEARNED**

In complex projects that involve large resources and therefore require a rigid time schedule for obtaining the required permits, creating confidence of all parties involved (regulators, public) is of paramount importance to negotiate on a rational basis. To create confidence, one may

- get people involved by making risk analysis tools available to everybody,
- accept perceptions of relative risks and reproduce them, if possible, by scientific methods,
- give people the feeling of becoming an insider in the decision process,
- discuss openly the real consequences of "risky" options that seem unacceptable in the beginning.

Rational arguments which would otherwise be dominated by fears and distrust are now more likely to be accepted by regulators and the public.

**REFERENCES**

NUCLEAR EMERGENCY PLANNING AND RESPONSE IN INDUSTRIAL AREAS: A QUALITATIVE STUDY IN THE ANTWERP HARBOUR REGION

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ABSTRACT
Substantial economic losses and potential dangerous situations may result when industrial companies unexpectedly have to shut down their activities in an abrupt way. This might be the case if a serious accident, either of a nuclear or a chemical origin, takes place in the very close vicinity, provoking the decision to evacuate the workers or to have them sheltered. The harbour region near Antwerp (Belgium) is an example of a site with a very important concentration of, mainly petrochemical, industrial enterprises close (within a few kilometres) to a nuclear power station (4 Pressurised Water Reactors at Doel).

During 1998, the safety and prevention advisors of 9 companies have been interviewed to gain an insight into the scale and the relative importance of the various economic costs, the secondary risks, and the practical difficulties that may arise. Moreover, the appropriateness of the existing nuclear emergency decision structure and intervention philosophy applicable in Belgium have been verified. In the paper, the main conclusions that can be drawn from this exercise will be sketched, including some recommendations to increase the efficiency of implementing urgent nuclear countermeasures in industrial areas.

INTRODUCTION
In literature [1, 3, 5, 6] often reference is made to the substantial economic losses and potential dangerous situations that might result when industrial companies unexpectedly have to shut down their activities. In the Antwerp harbour region, the reason for such an unplanned shut-down could be the decision to (preventively) evacuate the workers due to an alarm situation in the nearby nuclear power plants of Doel or in any adjacent industrial factory.

The prevention advisors of 9 industrial companies in this region have been interviewed about this problem. These companies are active in petro(chemistry) (5/9), the storage and treatment of hazardous materials (2/9), waste disposal (1/9) and energy production (1/9). Table 1 summarises some important data, characterising these firms.

<table>
<thead>
<tr>
<th>Employees (including contractors)</th>
<th>Turnover (million EUR)</th>
<th>Added Value (million EUR)</th>
<th>Installations (million EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>5</td>
<td>0.65</td>
<td>0.1</td>
</tr>
<tr>
<td>Maximum</td>
<td>1170</td>
<td>359</td>
<td>235</td>
</tr>
<tr>
<td>Median</td>
<td>188</td>
<td>80</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 1. Some characteristics of the participating companies.

RESEARCH QUESTIONS AND METHODOLOGY
The purpose of the interviews consisted in finding an answer to the following questions:
1. What are the scale and importance of the several economic costs and practical difficulties that may arise when a countermeasure (e.g. evacuation) is imposed on industrial companies?
2. Is the Belgian nuclear emergency response decision structure [4] in which the government unilaterally imposes its decisions on the threatened companies the most efficient in order to mitigate the costs and potential dangerous situations observed in 1? The necessary data was collected by means of semi-structured interviews [2, 7] on the basis of a questionnaire that was compiled in close collaboration with a number of experts in the field of nuclear emergency planning and industrial safety. Each company took part on a voluntary basis.

RESULTS
The following results were obtained with respect to the first research question.
- The two companies without production processes can almost instantaneously (15 minutes or less) halt their activities and evacuate the workers. The companies with (mostly continuous) production processes, require considerably more time. Their production can be shut down in two ways: a "completely safe and economic justified way", i.e. a shut-down without any residual risks, nor important start-up costs due to damage to the installations, and a "safe" way, i.e. an emergency shut-down respecting the safety of the workers and the population, without taking into account the economic implications of this stop; some residual risks may still exist (e.g. the presence of toxic materials in the installations). For the companies involved, the first shut-down mode takes 1 hour to 4 days; the second one 15 minutes to 8 hours. Although the implications of both shut-down procedures differ drastically from firm to firm, some observations are valid in general (Table 2).

<table>
<thead>
<tr>
<th>Worker exposure</th>
<th>Range</th>
<th>Median</th>
<th>Range</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration shut-down</td>
<td>15 min → 96 hrs</td>
<td>4 – 5 hrs</td>
<td>5 min → 8 hrs</td>
<td>1 h</td>
</tr>
<tr>
<td>Number of workers</td>
<td>1 → 40</td>
<td>&lt; 10</td>
<td>1 → 25</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Activities in open air</td>
<td>&lt;20% → &gt; 80%</td>
<td>40% - 60%</td>
<td>0% → &gt; 80%</td>
<td>20% - 40%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economic impact</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of added value</td>
<td>0 - 1 MEur/day</td>
<td>0.09 MEur/day</td>
<td>0 - 1 MEur/day</td>
<td>0.09 MEur/day</td>
</tr>
<tr>
<td>Duration start-up phase</td>
<td>0 - 6 days</td>
<td>3 hours</td>
<td>0 - 30 days</td>
<td>48 hours</td>
</tr>
<tr>
<td>Costs to installations</td>
<td>0 - 0.0125 MEur</td>
<td>0</td>
<td>0 - 1.25 MEur</td>
<td>Moderate</td>
</tr>
<tr>
<td>Loss of reagents, reaction products</td>
<td>0 - 0.016 MEur</td>
<td>0</td>
<td>0 - 0.16 MEur</td>
<td>0</td>
</tr>
<tr>
<td>Loss of market share</td>
<td>Yes</td>
<td>Not applicable</td>
<td>yes (=&gt; A)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Secondary costs</td>
<td>Yes</td>
<td>Not applicable</td>
<td>yes (=&gt; A)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Environmental damage</td>
<td>No</td>
<td>Not applicable</td>
<td>Moderate</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

Table 2. Comparative overview 'completely safe shut-down' versus 'safe shut-down'.

- The worker exposure will be smaller in case of a safe shut-down as both the time needed to shut down and the required number of workers in open air are smaller.
- However, a safe shut-down may result in a much longer start-up phase afterwards, implying an increased immediate loss of added value, but also the potential loss of market share. This shut-down procedure may also yield considerable costs to the installations and result in larger losses of reagents/reaction products. Damage to the environment cannot be excluded, but the implications remain moderate in general.

These data should be interpreted carefully as some interrelations are not indicated in this table. As such, it is not (necessarily) that under a worst case scenario 40 workers should mainly (>80%) perform outdoor activities during 96 hours to shut down the production processes in a fully safe and economic justified way.
• After the production processes have been shut down most companies require one or more workers to guard their territories for economic (prevention of theft) or safety reasons (for instance: to observe and fight any spontaneous combustion of particular products).

• In case the available time to shut down the production processes is smaller than the time needed for a safe emergency stop, important domino-risks (fire, release of toxic materials) may result in all companies with production processes. These secondary risks should absolutely be avoided and are of major importance for those companies that require a considerable amount of time to be safely shut down.

• All companies have sheltering possibilities that provide similar protection against ionising radiation than residential houses. It is possible to continue the production for a few hours with a limited number of staff (possibly requiring short interventions in open air).

With respect to the second research question, it can be concluded that the current nuclear emergency response decision structure and intervention philosophy probably show some limitations with respect to the implementation of countermeasures in industrial areas.

• The traditionally applied radiological intervention levels insufficiently take into account the economic implications and potential risks described above. Most of the prevention advisors think that for workers other intervention levels than those applicable in residential areas must hold in situations where utilisation of the latter may result in important domino-risks. In such situations, even the implementation of distinct countermeasures can be considered for the different business units: the final target needs to be optimisation of safety, both nuclear AND chemical; economic aspects are only to be considered when there is no direct danger for the workers, the population and the environment.

• Avoiding domino-risks may require to expose a limited number of workers during a short period of time to ionising radiation. The majority thinks that the workers will be prepared to execute the necessary actions in case of a threat of (6/9) or an effective (7/9) chemical release, provided that the necessary individual protective measures are foreseen. The opinions are dissenting with respect to the behaviour of the industrial workers in case of a nuclear threat or effective release. Nuclear risks are perceived to be more dangerous than chemical risks, due to the workers' unfamiliarity with the nuclear (8/9).

• The support of intervention decisions in industrial areas requires information the federal authorities cannot dispose of in a fast and efficient way, e.g. the status of the industrial facility. All prevention advisors indicate the need for technical information with respect to the severity of the (possible) release, as well as specific advise with respect to the necessary protective actions in a very early stage, in order to avoid problems due to a lack of time remaining before the evacuation has to be initiated. The majority of the prevention advisors prefers to be informed by the nuclear power plant operator (8/9) and the regional authorities (7/9); a majority (6/9) also attaches great interest to the information obtained from the federal authorities because of its objective character.

RECOMMENDATIONS
The following actions would increase the efficiency of countermeasures in industrial areas:

• Every industrial company in the emergency planning zone of a nuclear power plant could prepare specific and applicable actions in a well-elaborated 'industrial' nuclear emergency plan, preferably including the advice of a nuclear expert.
• Within each company, the members of the safety services could be introduced in the field of nuclear risks. This would improve communication during a nuclear crisis, and as such, increase the probability of successfully implementing particular actions.

• It could be considered to have the nuclear power plant operator not only immediately inform the government in case of an incident, but also the surrounding industrial companies. This would allow them to initiate a number of preliminary actions, in anticipation of the competent authorities' advice. As such, the loss of costly time could be strongly reduced. However, this enhances the problem of liability.

• In the pre-release phase, it is important not to implement too intervening countermeasures too conservatively, supposing they can be easily scaled-down afterwards. In industrial regions, this results in important economic losses or creates considerable secondary risks.

• Finally, it has been found that secondary risks often can be avoided by shortly exposing a very limited number of workers to radiation (for instance: short operations in open air during a safe shut-down), resulting in doses possibly exceeding the traditional intervention levels. It can be considered to draw up a distinct set of intervention levels for this small group of workers, taking into account the following principles:
  - every exposure must be necessary to avoid or reduce important (chemical) risks;
  - the intervention workers should dispose of the necessary individual respiratory protection devices and protective clothing, and be well-trained on beforehand.
  - deterministic effects should be avoided.

It is important not to treat the issue of implementing countermeasures in industrial areas as such, but to integrate it in a global (nuclear) emergency management policy. This implies the integration of the 'industrial' nuclear emergency plans in the national nuclear emergency plan, the optimisation of the information and communication streams between the nuclear plant operator, the industrial company and the regional and national authorities, etc.

REFERENCES


ACKNOWLEDGEMENTS

We are grateful to all that participated in the preparation of the questionnaire, and especially to the prevention advisors and their companies willing to collaborate in this study.
ABSTRACT
A significant number of biomass fuelled electricity-generating projects which have gained government-backed contracts in the UK have failed to come on stream. By March, 1999, only six of 32 projects were live, representing 64MW out of a total contracted of 256MW. Although there is widespread support from the general public for the use of renewable energy sources, many plants have met considerable siting problems. This case study, wherein a 20MW straw-burning generating plant in south-west England, was refused planning permission, reveals the salience of trust and the perception of fairness in siting debates.

1 INTRODUCTION
This study, completed in 1996, examines the risk communication processes included in the debate around a planning application for a straw-burning generating plant at Calne, North Wiltshire, during 1994. The proposal was submitted by a company jointly owned by a farmers’ co-operative and Southern Electric Power Generation, a subsidiary of Southern Electric plc. The proposed 20MW plant was the subject of a bid for a Non-Fossil Fuel Order (NFFO3). North Wiltshire District Council refused planning permission in October, 1994, and in December, 1994, the bid failed to win a government NFFO contract. Planning permission was refused, in spite of planning officers’ recommendations of acceptance, after a well-orchestrated campaign by a single-issue lobby group. This paper examines the salience of trust and fairness within a risk communication strategy for a controversial siting.

2. PROBLEMS OF PLANT SITING
The siting of power plants is widely recognised as a major problem (Linnerooth-Bayer and Davy 1994, Kunreuther et al 1993). There is significantly more controversy over siting power plants, chemical plants and landfill sites now than there was 25 years ago (Kunreuther et al, 1993). This has also been true of bids to site power plants using renewable fuel sources. Interest in using renewable fuel sources to generate electricity in the UK has been kick-started by the government’s Non-Fossil Fuel Orders, through which the government aims to achieve 1,500MW of new electricity-generating capacity from renewable sources by 2000. By mid-1999, 274 plants were live out of a total of 933 contracts awarded. These were generating 677MW out of a total contracted of 3,639MW. (ETSU 1999) Clearly, the orders will barely achieve 50 per cent of the government’s target by 2000. Biomass was not included in the 1998 NFFO 5 order as requested by the trade body and the holders of current NFFO biomass contracts. This delay was to allow developers time to devise projects with a real prospect of success (ETSU 1998). By mid-1999, although 32 NFFO biomass contracts had been awarded, only six projects were generating, (64MW), the bulk of which uses poultry litter as fuel. One plant was under construction in North Yorkshire (energy crops) and another in East Cambridgeshire (straw) was due to come on stream in September 2000.

Government policy is to stimulate the development of new and renewable energy sources wherever they have the prospect of being economically attractive and environmentally acceptable (DTI 1994). Successful NFFO bids have a guaranteed price during the contract.
Projects are selected by price and an assessment of sustainability at the end of the contract. The government's second criterion of environmental acceptability has been more difficult to achieve. Key issues in siting difficulties for combustion plants have been visual impact and public perception of health risks (Sinclair 1998). The problems of obtaining planning permission for NFFO projects have been widely recognised (DTI 1994, William and Limbrick 1995 and Offer 1994).

Most of the public appear to support renewable energy, but there are inevitable objections to siting combustion plants (DTI 1994). Many renewable technologies, such as those using agricultural and forestry wastes, hydro, wind and energy crops, bring power generation to areas previously free from major industrial sites. The DTI (1994) comments that an equitable balance needs to be struck between the global benefits of new and renewable technologies in reducing harmful emissions and localised environmental concerns about the plants. The DTI helps local authorities to quantify the benefits and impacts of renewables deployment so it can be compared with conventional fuels (DTI 1994). However, as most renewables power plants are in areas far from the traditional homes of fossil-fuelled plants, residents and environmental groups compare the impact of a renewable source power plant with what was there before — usually agriculture or low-impact development. People have many different reasons for valuing the environment and many varying commitments, so siting debates are often surrounded by conflict (Royal Commission 1998).

3. THE CALNE CASE STUDY

3.1 Methodology
A multi-method approach was used to uncover the facts and the attitudes, perceptions and behaviours of people involved in the debate and the decision-making process and bystanders from the locality. This included interviews with those active in the debate and the decision-making process, a questionnaire administered to 50 residents, a content analysis of local, regional and national newspapers from February 1994 to January 1995, and a document search. The questionnaire covered opposition towards the plant, action taken, the influences and reasons which led to the adoption of these stances and opinions on the trustworthiness of policy makers, the developers and environmental groups. Respondents were asked to agree or disagree with 11 statements, in an attempt to discover attitudes towards involuntary risk, Nimbyism, the role of elected representatives and trust and fairness with regard to industrial operations in general.

3.2 Questionnaire results
Of the sample, 46 per cent were against the plant, 30 per cent for, 14 per cent not bothered and 10 per cent undecided. Respondents were most frequently against the plant because of air pollution (40 per cent were concerned) and visual impact and health worries (both 32 per cent). Air pollution and visual impact were each given as the most important reason for being against the plant by 10 per cent, while 12 per cent were most concerned by health worries.

![Table 1: Percentages of sample and degree of trust](image-url)
3.3 Trust
The numbers of people concerned by air pollution may be linked to widespread distrust of plant operators – 72 per cent felt that you could not trust plant operators never to break the rules. Lay people have to take emissions data on trust as they cannot know safe levels or assess emissions by looking at a chimney plume. The questionnaire results revealed a strong link between perceived vested interests and lack of trust (Covello 1992, Slovic 1993).

Most of the reasons given for lack of trust were that those involved were only in it for the money – or had other vested interests or hidden agendas. It has been shown that trust is strongly affected by past record (Petts 1995). Many residents were unhappy about the council’s part in a town housing project and the lack of action over the development of the site of a former sausage factory. Government inspectors were not widely trusted either – 32 per cent agreed that you can trust government inspector to check up on plant operators, while 34 per cent felt that you could not. Sixteen per cent thought that residents who lived near industrial plants always learned the truth about health risks or safety incidents, while 60 per cent disagreed. Sixty per cent of the sample agreed that doctors could be trusted more than most people to know what was in residents’ best interests.

3.4 Credibility of information
Bound up with trust in many cases, according to the results of the open-ended questions, was the issue of credibility of information (Earle and Cvetkovich 1994). In many cases the lobbyists’ policy of power through expertise (Jasanoff 1993) appeared to work. Many respondents said that they trusted the environmental groups, “as they knew what they were talking about.” Information given by the council or the developers was prone to be discounted because of perceived vested interests (Renn and Levine 1991). The council employed outside experts to check the developer’s data on emissions. But the Coal Research Establishment’s assurances seemed to carry little weight compared with the lobbyists’ emissions experts and a letter to the local newspaper from several town doctors, saying that they would be “the professionals struggling to help people whose health might be damaged by a straw-burner.”

3.5 Fairness
Fairness was an issue, as in other risk debates (Kasperson 1986). Many people could not see why Calne should host the plant, although 52 per cent of the sample agreed that it would be fair to put an electricity generating plant in Calne and 24 per cent disagreed. Having a convenient electricity sub-station and being 20 minutes from the M4 did not seem sufficient reason for everybody. Ten per cent of the sample included “lack of benefits for Calne” as a reason for being against the plant, but it was the most important reason for no one. Several people mentioned that if it had brought more jobs they might have been keener. Questions raised over the plant’s viability impacted with people’s concerns over the fairness of the siting. Calne’s position at the western rim of a straw producing area seemed to many to disqualify it as a host to a straw burning plant. Of 257 farms contracted to supply straw, only 20 were west of Calne and 88 farms were more than 50 miles away. The area from which straw was to be collected included most of central southern England, which led to concerns that the transport of the straw would negate any greenhouse gas gains made from using a renewable energy source.

4. CONCLUSION
A poor risk communication strategy leading to lack of trust in developers and planning authorities can bring siting problems for renewable energy projects. This has been responsible for some of the failures
of projects awarded NFFO contracts. Gaining planning permission can be one of the most significant and costly hurdles for developers of NFFO projects (Jackson and Lofstedt 1998, DTI 1994, Offer 1994, Williams and Limbrick 1995). Rejigging the system to mitigate the global-gains-but-local-costs of the NFFOs could help this. One way of doing this would be to encourage schemes to bring local benefits with them such as low-cost district heating, local ownership or large numbers of jobs in associated projects (Collier and Lofstedt 1997, Kunreuther 1992). The NFFO system currently encourages large projects for many technologies so that start-up costs can be laid off the contract term (Williams and Limbrick 1995). Regulations that did not discriminate against smaller projects would make many NFFO projects more acceptable locally.

REFERENCES
ETSU 1998. NFFO Fact Sheet 12, issued by ETSU for the Department of Trade and Industry.
ETSU 1999. NFFO Fact Sheet 11, issued by ETSU for the Department of Trade and Industry.
In 1998, the media revealed in France the infringement of transport regulation relative to the external surface contamination of spent nuclear fuel shipments. IPSN was asked to estimate the dosimetric impact on the people potentially exposed to these contamination spots. The conservative and realistic dosimetric assessments performed are presented in this paper. They highlight that irradiation from the spent fuel itself is the main exposure source, comparatively to that from the external contamination of the casks.

Among the measures taken by the nuclear operators to recover a situation in accordance with the regulation, the main action consists in increasing the number of surface controls and décontaminations before the departure of the train. Therefore, the time exposure of the workers in charge of these activities at the nuclear power plants increases and so does the collective dose of this group of workers. Besides, the expected benefit from this additional cleaning on the exposure of the railway men is relatively low. This management involves transfert of the radiation risk from the public (neighbouring population and railway operator workers who are not radiation monitored workers) to the workers of the nuclear industry. However, even the pessimistic estimations point out that the dosimetric cost of these decisions remains reasonable, compared to those of other operations in the nuclear industry. Actually, the first results of the dosimetric survey do not show a significant increase of the collective dose.
ICROD – AN EDUCATIONAL ATTEMPT OF CROSS-BOUNDARIES IN RISK-COMMUNICATION BETWEEN WEST AND EAST

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As known, possible solutions to problems of environmental pollution and industrial safety were addressed in the 1992 Rio Conference that introduced the concept of "sustainable development." They called for a reduction of the technological appetites of contemporary and future societies, and the allocation of funds for decontamination of the environment and neutralization of accumulated waste. Compliance with such proposed solutions potentially requires vast financial and physical commitments that may be reasonable expectations for many parts of the world. However, for people from FSU and East Europe who live in industrial countries with meager incomes and severe problems with environmental pollution and industrial safety, the national resources are needed and spent for more pressing doings. As a result a number of negative consequences already can be observed. For instance, rather low level of general culture and knowledge concerned to problems of industrial safety, environment and nature and individual protection in these East countries (on a comparison with countries of Large Seven). Besides, are failing of the appropriate chiefs competently formulate problems on these field, and lack of readiness of governments and public of these countries for appropriate financial and physical inputs. We seem, have found the available form of introduction of Know-How risk - technologies, which fully fits to the current condition of the crisis or faint regions and countries. This form - step by step informing of concerned to administrators and retraining of experts in the field of such risk - technologies, which in advance could be applied in conditions of extremely limited costs and resources. Such form assumes realization sequence of courses in frame of Instructional Centers on Risk Technologies for Optimization of Management Decisions in Sustainable Tomorrow (ICROD). The ICRODs are founding now and will work under the International Chair -Network UNESCO/ICES “Transfer of Technologies for Sustainable Development”
TRACK 3

SESSION 7

RISK PERCEPTION – EXPERTS VERSUS LAYPERSONS
SESSION 7

RISK PERCEPTION
EXPERTS VERSUS
LAYPERSONS
DEMOGRAPHIC DIFFERENCES IN RISK PERCEPTIONS AND PUBLIC PRIORITIES FOR RISK MITIGATION

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1000 adults (quota sampled across a broad demographic spectrum) were questioned about personal and societal risk perceptions associated with different technological, lifestyle and environmental hazards, as well as priorities for risk mitigation, trust in government to protect the public, and preferences for public involvement in risk management processes. The results indicated that hazards perceived as being high risk are not always those which the public believe should be a high priority for risk reduction. Low levels of trust in Government indicated the need to improve social trust in the risk management process, through improved transparency in regulatory frameworks, due emphasis on risk management decisions reflecting concern with public welfare, and dissociation of risk managers and risk management authorities from those individuals or organisations with public potentially vested interests. Perceptions of social exclusion from risk management decision making may be the most important determinant of risk perceptions. This was particularly evident for demographic differences based on ethnicity, gender, social group and income. Elevated risk perceptions may not be unrealistic considering that, gender excepted, many of these individuals are more likely to suffer poor health, be living in low quality housing, and have reduced access to educational opportunities. Individuals in all these groups also have less control over risk management processes at an executive level, particularly those associated with technologies and emerging technologies. Mechanisms should therefore be evolved which permit socially excluded individuals to contribute to the risk management process, through public participation in both the development of risk management strategies and prioritisation of risk management decisions.
Organophosphate (OP) compounds used in sheep dips have been a centre of debate and controversy related to potential adverse effects to the user (usually the Farmer or farm worker). Issues surrounding the use of such dip provide a case study for investigation of differences in risk/benefit evaluation factors used by different interest groups. The work aims to understand differences and similarities in factors influencing risk perception in three groups of the population; farmers, 'technical experts' (veterinary surgeons, scientists and medical practitioners) and the general public. SEMI-STRUCTURED INTERVIEWING BASED ON THE LADDERING TECHNIQUE (HINKLE, 1965) AND FOCUS GROUPS WERE USED TO DETERMINE UNDERLYING DIFFERENCES IN BELIEFS ABOUT THE RISKS OF ORGANOPHOSPHATES.

Where differences in perception are recognized then they may be accounted for in policy formulation resulting in regulations which are likely to be more generally acceptable and therefore more likely to be successfully implemented. IMPLICATIONS FOR POLICY FORMULATION ASSOCIATED WITH RISK COMMUNICATION TARGETED AT THE DIFFERENT GROUPS WILL BE DISCUSSED.
THE MILLENNIUM BUG CONTROVERSY IN THE NETHERLANDS?
EXPERTS’ VIEWS VERSUS PUBLIC PERCEPTION

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ABSTRACT
The Millennium problem, also known as year2000, Y2K or Millennium bug, confronts the public and experts with the pessimistic idea that on 1 January 2000 the hardware and software of essential computer systems may behave unreliably and unpredictably, affecting all sectors of society. Anecdotal news accounts have indicated that in several countries people worry about this particular risk and make preparations by laying up food supplies, batteries, candles, or by withdrawing their money from their bank accounts. In the Netherlands, the so-called Millennium Platform co-ordinates the activities in the various lines of business to mitigate the millennium risk and regularly informs the Dutch public. These efforts are quite costly, making the Millennium problem an important issue from an economie perspective. This study systematically examines the risk perception of both general public and computer experts, assessing a potential discrepancy between the layman’s and the expert’s judgement, as has been observed in other risk areas. Two surveys were fielded, the first among a random sample of the Dutch population (n=253), the second among a sample of computer experts (n=91). Results indicate that respondents do not perceive the Millennium bug to be a major threat. Overall, lay people worry more, see the issue as more personally risky, and think the level of public awareness is higher than experts do. Computer experts feel more capable of taking mitigating actions than lay people, and are more convinced that these actions are adequate. The consequences for risk communication about the Y2K issue are discussed briefly.

INTRODUCTION
Computer technology has become an essential part of society. Without proper mitigation of the Millennium bug, severe consequences are foreseen in the financial and business world, military and health care organisations, nuclear power plants, the chemical industry, the energy supply, transport sector and in small and medium sized businesses. The Millennium bug shares many characteristics with other so-called ‘low probability, high consequence’ risks from earlier risk perception studies. However, in contrast to many of these other risks the supposed consequences have been forecasted but not yet observed and people not (yet) experienced any disastrous ‘computer accident’ attributable to the Millennium bug. The Millennium bug issue is also characterised by a rather clear deadline, which may increase worry or extreme (pseudo) mitigating behaviour when the turn of the century comes nearer and nearer.

With many ‘low probability, high consequence’ risks a discrepancy between ‘lay persons’ views and experts’ opinions has been observed, attributed to different conceptualisations of the risk issue at hand (e.g. Fischhoff e.a., 1981; Kraus e.a. 1992). For example, risk perception literature quite often states that lay people judge a particular risk by the nature of its consequences, whereas experts may base their judgement on statistical or actuarial data. We assume that this discrepancy is hindering the adequate exchange of information between both experts and lay persons and other risk communication processes (Gutteling & Wiegman, 1996). The question underlying this study is whether in the Netherlands such a discrepancy also exists with respect to the Millennium issue. Risk communication about the Millennium
bug is a distinct activity in our country, and computer experts play an important role in the communication process. However, it is not clear what determines the perceptions and intended behaviours of both lay people and experts. Neither is it clear whether the conceptualisation of the issue by both actor groups may facilitate or frustrate the communication process.

Both the news media and the campaigns of the Millennium platform have made the Dutch public aware of the Millennium problem for several years now. In the period in which this study was fielded, both types of communication emphasised the potentially severe consequences. The platform launched a campaign directed at several business sectors of society with the ominous slogan 'we have to take care of the Millennium problem before it takes care of us'. Although the general public was not the target group for this campaign, it included advertisements in the general press. We may expect that this type of communication is more than likely to increase perceptions of risk and worry. So, our expectation would be that in general the lay public, due to the dramatic framing, might see the Millennium issue as serious, although one may feel that the probability of occurrence of Millennium problems is small. Because of the lack of previous disastrous experiences the level of risk perception may be low with a low level of intentions to take risk-mitigating actions. We assume that experts, who are less dependent on dramatic campaigns for their perception of the issue, may base their judgement the Millennium bug on their knowledge of the technology. We would expect experts to perceive the problem as less severe than the lay public.

METHOD
Two surveys were fielded in April 1999. A questionnaire was send to a random sample of Dutch households, taken by the Dutch Postal Services. The second, identical, questionnaire was mailed to a sample of persons working as Computer Technology Scientists at Dutch Universities or at Dutch Universities computer support departments. Both questionnaires comprised questions aimed at the perception of the Millennium risk in 6 different situations, namely 1) the hospital, 2) financial matters, 3) retail trade, 4) transport, 5) in people's own home and 6) the energy supply. These situations were based on a pilot study with lay people, which indicated that the six situations differed with respect to the potential for personal injury or for financial damage. Risk perceptions measured were (on 5-point scales): risk probability, personal risky consequences, societal risky consequences, awareness of the problem among both the public and experts, the level of worry by the risk, the assessed self efficacy for risk mitigating action, the outcome expectancy of these actions, and the intention of taking risk mitigating actions. Furthermore, we measured Millennium bug attitudes regarding the attributed responsibility for the problem with computer technology in the first place, the trust in machines and organisations that claim to be Millennium proof and the overall evaluation of the approach of the problem in our country. Demographics and computer literacy were measured as well.

RESULTS
In total, 353 people returned questionnaires. 91 respondents who indicated to be employed in the Computer Business were considered as experts, 253 respondents were categorised as lay persons. Response rates were low (approx. 20% in both groups), indicating perhaps that the Millennium problem is not a hot issue in the Netherlands. So, generalisations from our data to both populations are to be made with extreme care. The number of respondents is adequate for comparative analysis between both groups. As a further check on the division of subjects we analysed risk perceptions between lay persons who indicated to be a computer illiterate, and
those having more experience because they use a computer at home or at work. No

differences were found, allowing us to consider the lay persons as a homogeneous group.
Table 1 shows the results for the aggregated risk perceptions (all aggregated risk perception
scales are sufficiently reliable, Cronbach’s alpha is .80 or higher), as well as the behaviour
related and other variables. The average levels of risk perception are low, indicating
respondents do not perceive the Millennium bug to be a major threat. Overall, lay persons and
computer experts express a different level of worry about the Millennium bug, the riskiness of
personal consequences, and the assumed public awareness of the issue. Lay people worry
more, see the issue as more personally risky, and think the level of public awareness is higher
than experts do. In the behavioural domain, computer experts feel more capable of taking
mitigating actions than lay people, and also are more convinced that these actions are ade­
quate. Lay people and computer experts seem to agree that computer people themselves are to
blame for the existence of the Millennium problem. Lay people express more trust in ma­
chines or organisations that claim to be ‘Millennium proof’ and are more convinced that in
our country adequate measures are taken to cope with the Millennium bug. Experts have
much more reservations here. Compared to experts, lay people are more convinced that
government agencies should do more to inform the public about the Millennium risk.

Table 1: Millennium Bug issue: Perception and behaviour of ‘lay persons’ and ‘experts’.

<table>
<thead>
<tr>
<th></th>
<th>‘lay persons’</th>
<th>‘experts’</th>
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</thead>
<tbody>
<tr>
<td><strong>Risk Perception related</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worry 1</td>
<td>2.56</td>
<td>2.22</td>
<td>7.20**</td>
</tr>
<tr>
<td>Probability of occurrence 2</td>
<td>2.74</td>
<td>2.69</td>
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<tr>
<td>Personal risky 1</td>
<td>2.47</td>
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<tr>
<td>Societal risky 1</td>
<td>3.02</td>
<td>2.80</td>
<td>3.13</td>
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<tr>
<td>Assumed public awareness 1</td>
<td>2.68</td>
<td>2.30</td>
<td>8.03**</td>
</tr>
<tr>
<td>Assumed expert awareness 1</td>
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<td>3.84</td>
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<td><strong>Behaviour related</strong></td>
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<td></td>
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<tr>
<td>Assessed self efficacy mitigation 1</td>
<td>2.77</td>
<td>3.14</td>
<td>8.16**</td>
</tr>
<tr>
<td>Outcome expectancy mitigation 1</td>
<td>2.86</td>
<td>3.15</td>
<td>4.98*</td>
</tr>
<tr>
<td>Intention to mitigate 3</td>
<td>1.11</td>
<td>1.12</td>
<td>&lt; 1</td>
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<tr>
<td><strong>Other variables</strong></td>
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<td></td>
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<td>3.26</td>
<td>2.70</td>
</tr>
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<td>Trust claims and organisations? 1</td>
<td>3.63</td>
<td>3.17</td>
<td>18.38***</td>
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<tr>
<td>More info needed for public? 1</td>
<td>3.62</td>
<td>3.19</td>
<td>6.70**</td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01, *** p < .001

1 5-point scales with 1 disagree, 5 agree, 2 5-point scales with 1 very small, 5 very high, 3 no action intended, 2 action intended for every of the 6 situations

In general, major differences exist in the perception of the six risk situations (see also table 2
for significant differences in perceptions and behaviour related variables between lay people
and experts). The energy supply is seen as most risky, both on a personal level and for society
as a whole. Problems in this sector are not seen as easily solvable. Lay people and experts
alike feel not capable to take adequate mitigating action themselves, and expect possible ac­
tions to be inefficient. So, it is not surprising that people worry most about the Millennium
issue regarding the energy sector. A millennium problem in hospitals is also a matter of worry
for many, although respondents perceive it as less risky than the energy risks. Respondents do
not feel capable of taking measures themselves. Personal measures are seen as inefficient as
Almost 25% of the respondents think the probability of occurrence of problems in the energy sector or the hospital is large. The transport sector is perceived as the domain in which the occurrence of a Millennium problem is most likely. The Millennium problem in this area is seen as not easily solvable, and perceived as risky for society as a whole. The personal consequences are perceived as less risky, possibly because people feel rather capable of taking adequate mitigating action.

### Table 2: Six specific millennium bug risks: Significant differences in risk perception between ‘lay persons’ and ‘experts’.

<table>
<thead>
<tr>
<th></th>
<th>Hospital</th>
<th>Financial</th>
<th>Retail trade</th>
<th>Transport</th>
<th>Own home</th>
<th>Energy supply</th>
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<td>Worry</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>**</td>
<td>***</td>
<td>#</td>
</tr>
<tr>
<td>Assumed public knowledge</td>
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<td>***</td>
<td>*</td>
<td>ns</td>
</tr>
<tr>
<td>Personal risky</td>
<td>ns</td>
<td>#</td>
<td>ns</td>
<td>ns</td>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>Self efficacy</td>
<td>**</td>
<td>#</td>
<td>*</td>
<td>ns</td>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>Outcome expectancy</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>***</td>
<td>ns</td>
</tr>
</tbody>
</table>

\# p<.10, * p<.05, ** p<.01, *** p<.001

Lay people and computer experts disagree most about the Millennium problem in their own homes. Although this risk situation is the least salient in our questionnaire to both lay people and experts, the former worry significantly more, assess the personal risk as higher, and feel much less capable of coping with the risks themselves. Furthermore, lay people express less faith in self-applied risk mitigation at home than experts. Additional Millennium risk communication aimed at the general public should focus on this particular situation. The Millennium problem in the retail trade is not seen as very risky and only few people express worry about this risk. Although the occurrence of a Millennium problem in the retail trade is seen as likely by more people than the previous risk, people feel more capable of taking effective mitigating action, e.g. by laying up sufficient amounts of food. Both lay people and experts think that the Millennium issue in the financial sector is not very risky for them personally. So, this issue does not bring on many worries. People are confident to be able to take adequate measures, e.g. by withdrawing some extra cash from the bank accounts.

### CONCLUSIONS

We have observed several differences in risk perceptions and behaviour related variables between lay people and experts. However, we found no indication for the existence of an insuperable controversy between both groups, because in absolute terms these differences appear to be rather marginal. Several explanations for this finding, which is rather different than what has been reported in earlier comparative ‘lay people vs. expert’ studies, come to mind. Perhaps the Millennium issue is not salient enough (yet) or people are convinced that adequate measures are taken, so no real danger exists. As long as no Millennium ‘disasters’ are reported this may continue. However, later in the year the risk may become more salient. We will find out by replicating this study by the end of the year 1999. Another explanation is that the University experts may not be fully aware of all problems in the Millennium practice. So, in a second follow-up we will approach experts working in the field. And finally, perhaps the Millennium publicity has reassured both lay people and experts. We will address the question of the effects of the risk communication in the replication study as well.
BIBLIOGRAPHY


ECOLOGICAL AND PROFESSIONAL RISKS PERCEPTION BY STUDENTS AND ITS POSSIBLE DETERMINANTS

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ABSTRACT
An epidemic of radioanxiety, originated in Russia as aftermath of the Chernobyl accident, entailing the main burden for society, hasn't come to the end; what's more, there is also the upsurge of other ecological, specifically - toxicological, anxiety. It has mainly social roots, only partially fed by accidents. In this work radiation and toxicological risks perception and its determinants are studied in the group of 200 male third year medical students, as the most interested and, in the future, opinion-forming section of population.

As distinct from previous, the study subject is considered (1) in ecological and professional aspects, (2) in comparison with state and trait anxiety of a person, (3) before and after learning the radiobiology and toxicology course. Participants filled in three questionnaires. First questionnaire, developed on the basis of previous experience, covered background data, perception of risks (in ecological and professional aspects), information and knowledge, personal attitudes. Second questionnaire was based on Russian-adapted STAI method (state and trait anxiety inventory). Third was questionnaire for self-assessment of general physical and mental state. For data processing the program STATISTICA is used. Preliminary results have shown that risks from radio- and toxicological contamination together with transport accidents are rated in the most dangerous group among sixteen risks of everyday life, which confirmed starting considerations. In professional approach risks from military conflicts, radiation and chemical accidents are rated in the number of the most dangerous. Meanwhile state and trait anxieties were mostly in the normal limits. Ecological anxiety is little affected by learning the radiobiology and toxicology course. Correlation between variables and predictors and connected issues are discussed. Apparently, scientific, utilitarian and moral aspects of risk perception are insufficiently represented in learning and research.

INTRODUCTION
An epidemic of radioanxiety, originated in Russia as aftermath of the Chernobyl accident, entailing the main burden for society, hasn't come to the end; what's more, there is also the upsurge of other ecological, specifically - toxicological, anxiety. It has mainly social roots, only partially fed by accidents. So investigation of risk perception determinants is of interest. The hypothesis is that risk perception variance is determined not only by risk dimensions, but also by some personality features, like attitudes and predisposition and so on.

MATERIAL AND METHODS
In this work radiation and toxicological risks perception and its determinants are studied in the group of 200 male third year medical students, as the most interested and, in the future, opinion-forming section of population. Students are 19-20 years old, have no children. A questionnaire was elaborated in a pilot study (with 50 students); here a sample of 150 respondents is represented. As distinct from previous, the study subject is considered (1) in ecological and professional aspects, (2) in comparison with state and trait anxiety of a person, (3) before and after learning the radiobiology and toxicology course. Participants filled in
three questionnaires. First questionnaire, developed on the basis of previous experience, covered background data, perception of risks (in ecological and professional aspects), information and knowledge, personal attitudes. Second questionnaire was based on Russian-adapted STAI method (state and trait anxiety inventory). Third was special questionnaire for self-assessment of general physical and mental state. For data processing the program STATISTICA® is used.

RESULTS AND DISCUSSION

In Table 2 toxicological and radiation risks are rated as general ecological risks among 14 risks.

Table 2 Judgements of radiation and toxic environment by students among other risks

<table>
<thead>
<tr>
<th>NN</th>
<th>Factors of danger</th>
<th>Responses in a 5-point scale (from 1 – no danger. to 5 – the highest danger), %</th>
<th>Mean grade X(m)</th>
<th>Rank (by mean grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>violent crimes</td>
<td>8.7 24.7 51.3 14.0 1.3</td>
<td>2.75 (0.07)</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>military conflicts</td>
<td>13.3 31.3 28.7 16.0 10.7</td>
<td>2.79 (0.10)</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>transport accidents</td>
<td>6.7 30.0 34.7 22.7 10.0</td>
<td>2.91 (0.08)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>job traumas</td>
<td>20.0 38.7 32.0 8.7 0.7</td>
<td>2.31 (0.07)</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>domestic traumas</td>
<td>19.3 41.3 32.0 6.7 0.7</td>
<td>2.28 (0.07)</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>radiation environment</td>
<td>24.0 26.7 20.7 14.7 14.0</td>
<td>2.68 (0.11)</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>drinking of alcohol</td>
<td>6.0 38.7 18.0 4.0 3.3</td>
<td>2.00 (0.08)</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>use of narcotics</td>
<td>49.3 11.3 6.0 13.3 20.0</td>
<td>2.43 (0.13)</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>smoking</td>
<td>36.7 26.7 22.0 10.7 4.0</td>
<td>2.19 (0.09)</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>toxic environment</td>
<td>6.0 26.7 44.7 16.7 6.0</td>
<td>2.90 (0.08)</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>AIDS</td>
<td>17.3 29.3 30.7 9.3 13.3</td>
<td>2.72 (0.10)</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>healthcare deficit</td>
<td>17.3 37.3 30.7 13.3 1.3</td>
<td>2.44 (0.08)</td>
<td>9</td>
</tr>
<tr>
<td>13</td>
<td>economic failure</td>
<td>17.3 26.0 39.3 11.3 6.0</td>
<td>2.63 (0.09)</td>
<td>8</td>
</tr>
<tr>
<td>14</td>
<td>nervous stresses</td>
<td>16.0 32.7 28.7 15.3 7.3</td>
<td>2.65 (0.09)</td>
<td>7</td>
</tr>
</tbody>
</table>

One could see that by rank toxicants and radiation in environment are set in the upper half of the table, with ranks (r) 2 and 6, accordingly, together with risks of violent deaths (transport accidents, hostilities and assaults, r 1,3,4) and AIDS (r 5). In the middle are "societal" risks (stresses, economic and healthcare failure- r 7,8,9). At the bottom are the most accustomed risks: traumas (on the job and at home, r 11,12) and voluntary pernicious habits – narcotics, smoking and alcohol (r 10,13,14). Such ranking, perhaps, reflects some features of Russian society.

In Table 3 toxicological and radiation risks are rated as occupational risks for students’ future speciality among 11 risks.

Here the picture is even more demonstrative. Radiation and chemical accidents as the risk source came out on the top (r 1 and 2), together with participation in hostilities (r 3). Next were radiation and toxicants at the working place (r 4 and 5). It could be noted that professional radiation and toxicological risks were judged with higher mean grades than their ecological counterparts (risks in Table 2). Radiological and toxicological risks judgement is stable and reproducible. It was essentially repeated with little difference in successive parts of questionnaire (radiation knowledge etc). They are judged as very high, comparatively with
conditioned mortality rate. They entail hard economic burden for society, which makes assessment of the risk perception determinants topical. Less frightening occupational risks are in the lower half: electromagnetic fields (r 6), overlabour, stresses at work (r 7,8), unsuitable temperature (r 10). Curiously enough, specific occupational risks, linked with the medical use of radiation and chemicals (medicines), are at the bottom in ranking by medical students (r 9,11), which is at odds with their truth population value.

**Table 3 Judgements of radiation and toxicants among professional risks by medical students**

<table>
<thead>
<tr>
<th>NN</th>
<th>Professional risk factors</th>
<th>Responses in a 5-point scale (from 1 – no danger. to 5 – the highest danger), %</th>
<th>Mean grade X( m)</th>
<th>Rank (r) by mean grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>overlabour</td>
<td>5.3 29.3 44.0 18.0 3.3</td>
<td>2.85(0.07)</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>radiation on the job place</td>
<td>8.0 17.3 24.7 36.0 14.0</td>
<td>3.31(0.09)</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>ill-suited temperature</td>
<td>14.7 43.3 32.0 9.3 0.7</td>
<td>2.38(0.09)</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>toxicants in the job place</td>
<td>3.3 13.3 41.3 34.0 8.0</td>
<td>3.30(0.07)</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>electromagnetic fields</td>
<td>8.0 25.3 39.3 24.0 3.3</td>
<td>2.89(0.08)</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>radiation accidents</td>
<td>7.3 6.6 16.0 27.3 42.7</td>
<td>3.91(0.10)</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>involvement in hostilities</td>
<td>6.0 3.3 27.3 35.3 28.0</td>
<td>3.76(0.09)</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>chemical accidents</td>
<td>6.0 8.6 14.7 38.7 32.0</td>
<td>3.82(0.09)</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Roentgen-radiological medical procedures</td>
<td>14.7 40.0 34.0 10.0 1.3</td>
<td>2.43(0.07)</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>medicinal substances</td>
<td>22.0 43.3 30.0 4.0 0.7</td>
<td>2.18(0.07)</td>
<td>11</td>
</tr>
<tr>
<td>11</td>
<td>emotional stress</td>
<td>12.0 24.0 40.7 16.7 6.7</td>
<td>2.82(0.09)</td>
<td>8</td>
</tr>
</tbody>
</table>

First group of possible risk perception determinants we try includes indices of health, well-being and anxiety, namely: self-appraisal of health - (SAH); sum of responses to special questionnaire for self-assessment of general physical and mental state (PMS); analogous sums for state and trait anxiety (worry), appraised with STAI questionnaire (SA and TA), see Table 4. Values of these indices in the sample were more often satisfying or good. We failed to find correlation of health (SAH) with the risks judgement; whereas unexpected, though not strong, correlation tendencies were positive for general state and mood (PMS) and negative for general anxiety (SA). The results don’t contradict to data

Next determinants were grades of radiation and toxicological knowledge, (RK) and (TK), each ranked as the number of correct answers to 5 special questions, and their SUM (Table 4). They show weak negative correlation tendency with the risks judgement, which is consistent with

**Table 4 Correlations between risk judgement and its studied determinants**

<table>
<thead>
<tr>
<th>Risks (# as in tables 1 and 2)</th>
<th>health, well-being and anxiety</th>
<th>specific knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAH</td>
<td>PMS</td>
</tr>
<tr>
<td>1.6 radiation environment</td>
<td>0.01</td>
<td>0.20*</td>
</tr>
<tr>
<td>1.10 toxic environment</td>
<td>-0.05</td>
<td>0.25*</td>
</tr>
<tr>
<td>2.2 radiation on the job place</td>
<td>-0.02</td>
<td>0.20*</td>
</tr>
<tr>
<td>2.4 toxicants in the job place</td>
<td>-0.01</td>
<td>0.14</td>
</tr>
<tr>
<td>2.6 radiation accidents</td>
<td>0.07</td>
<td>0.15</td>
</tr>
<tr>
<td>2.8 chemical accidents</td>
<td>0.03</td>
<td>0.11</td>
</tr>
</tbody>
</table>
Some determinants, related to personality dimensions, were derived from respondents to special questions. Many of them show no correlation with the risks (Table 5), namely:

- self-appraisal of radiological or toxicological knowledge by 5-grade scale, or their sum (RTKS);
- difference between self-appraisal of specific knowledge and objective appraisal (by correct answers), considered as indices of self-assurance (SAS);
- internal or external position of locus of control of one’s life perspectives (LOC);
- personal activity attitudes, e.g. in preserving one’s health (PAH).

Several quantities, derivative of risk judgements, can be considered as personality dimensions and thus as risk determinants. In this capacity we try (Table 5):

- sum of judgements of social risks - as measure of (social) pessimism (SP);
- sum of judgements of different real risks - as measure of general pessimism (GP)
- sum of judgements of unreal risks (adverse celestial, extrasensory, geo-pathogenic influence, combined with one’s biorhythms, etc) - as measure of dimension superstition - realism (S-R);
- sum of judgments of risk of pernicious habits (alcohol, smoking, narcotics) –ASN, which could be the feature of realistic outlook or of general pessimism.

<table>
<thead>
<tr>
<th>Risks (# as in tables 1, 2)</th>
<th>RTKS</th>
<th>SAS</th>
<th>LOC</th>
<th>PAH</th>
<th>SP</th>
<th>GP</th>
<th>S-R</th>
<th>ASN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 radiat. environment</td>
<td>-0.05</td>
<td>0.13</td>
<td>0.00</td>
<td>0.09</td>
<td>0.19*</td>
<td>0.48*</td>
<td>0.34*</td>
<td>0.44*</td>
</tr>
<tr>
<td>1.10 toxic environment</td>
<td>0.10</td>
<td>0.09</td>
<td>-0.06</td>
<td>0.02</td>
<td>0.37*</td>
<td>0.44*</td>
<td>0.29*</td>
<td>0.47*</td>
</tr>
<tr>
<td>2.2 radiat. on job place</td>
<td>0.03</td>
<td>0.14</td>
<td>0.08</td>
<td>0.12</td>
<td>0.17*</td>
<td>0.42*</td>
<td>0.23*</td>
<td>0.37*</td>
</tr>
<tr>
<td>2.4 tox. on the job place</td>
<td>-0.04</td>
<td>0.12</td>
<td>0.04</td>
<td>0.05</td>
<td>0.15</td>
<td>0.30*</td>
<td>0.17*</td>
<td>0.29*</td>
</tr>
<tr>
<td>2.6 radiation accidents</td>
<td>0.11</td>
<td>0.09</td>
<td>0.03</td>
<td>0.07</td>
<td>0.05</td>
<td>0.25*</td>
<td>0.10</td>
<td>0.22*</td>
</tr>
<tr>
<td>2.8 chemical accidents</td>
<td>0.13</td>
<td>0.15</td>
<td>0.03</td>
<td>0.10</td>
<td>0.13</td>
<td>0.30*</td>
<td>0.08</td>
<td>0.20*</td>
</tr>
</tbody>
</table>

We could see definite correlation of ecological risk perception with indices of social and chiefly general pessimism, in accord with 1. Superstitions predisposition has also significant, although, contrary to our expectation, somewhat lesser correlation. It seemed that realistic outlook is linked with high ecological risk perception.

**CONCLUSION.**

Radiological and toxicological risks are perceived very high, at the top places among other risks, both in ecological and professional approaches, especially the risk of radiation or toxic accidents.

There is little, if any, correlation of the risks judgement with a number of logically probable determinants: self-appraisal of health and of general physical and mental state; state and trait anxiety; radiation and toxicological knowledge; self-appraisal of specific knowledge, self-assurance, position of locus of control, personal activities.

Definite correlations (0.2+0.5) with ecological risk perception showed indices of social and chiefly general pessimism, and, though somewhat lesser, superstition predisposition.

It could be concluded that there are other, socially conditioned, determinants.

Apparently, scientific, utilitarian and moral aspects of ecological risk perception are insufficiently represented in learning and need further research.
PUBLIC PERCEPTIONS OF THE RISKS TO HEALTH FROM AIR POLLUTION: THE IMPORTANCE OF PLACE

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   University of Durham

INTRODUCTION
Recent literature has highlighted the importance of the local context as the arena in which risk perceptions are framed and negotiated within the context of everyday life (Irwin and Wynne, 1996; Irwin et al. 1996; Walker et al., 1998). However, Walker et al. (1998, p13) argue that there is considerable potential for the further exploration of place as a factor in risk perceptions. Based on the findings from an empirical study focused on communities in north-east England, this paper explores the role of place in framing public perceptions of the risks to health from air pollution. We also present empirical material highlighting the ways in which air pollution and poor health are used as ‘dis-crediting characteristics’ (Goffman, 1963), to stigmatise one place whilst confirming the usualness of another. It is the language of relationships (Goffman, 1963) - the setting of boundaries around what is normal and different - and how this relates to place that we focus on in particular in our analysis.

EMPIRICAL STUDY
The arguments presented in this paper are based upon an empirical study which aimed to understand how people living in specific localities construct, prioritise and deal with risks to health from air pollution within the context of their everyday lives (Moffatt et al. 1999). The study focused on two quite different conurbations in north-east England: Teesside and Sunderland. Teesside is the site of the largest steel and petro-chemical complex in the UK, and approximately 12,000 people live within one kilometre of these industries. By contrast, most heavy industry in Sunderland (mainly ship-building and coal-mining) has now ceased, and lighter industries such as car manufacturing have risen to pre-eminence.

The study was based in 5 communities: 3 in Teesside and 2 in Sunderland. The study communities were selected so that comparisons could be made on the basis of socio-economic criteria and also geographical proximity to industry. The Teesside neighbourhoods comprised two materially deprived communities - one close to industry and once at a distance from industry - and one affluent community, also at a distance from industry. The two neighbourhoods in Sunderland comprised one materially deprived community and one relatively affluent community, which were broadly similar to the Teesside study communities on the basis of socio-economic indicators obtained from the 1991 Census of Population.
RESEARCH METHODS
The research incorporated two complementary research methods: a postal questionnaire survey of 5000 adults - which achieved a 58% response rate - followed by semi-structured, in-depth interviews with 41 respondents.

EMPIRICAL RESEARCH FINDINGS
Both quantitative and qualitative analyses highlighted the importance of place in framing perceptions of the risks to health from air pollution. Key findings will now be described, commencing with the findings from the survey.

In the survey we explored views on how air quality affects health at a general level by asking for respondents' views on which of a list of illnesses - including asthma, lung cancer and bronchitis - they felt could be affected by air pollution. Responses to this question did not differ by proximity to industry, age, sex, chronic illness or socio-economic status.

We then went on to ask respondents about how they felt the health of those living in their own community was affected by air pollution. These questions elicited much more marked differences between respondents. We asked whether the respondent personally, a member of their household, or anyone in their neighbourhood suffered from any illnesses which - in their own opinion - were affected, by local air quality. The community which stood out most in terms of responses to these questions was the community closest to heavy industry in Teesside.

Although respondents living here were not more likely to believe that they personally suffered from an illness affected by air pollution, they were significantly more likely to believe that other members of their community suffered from illnesses affected by air pollution (OR 0.27 99% CI 0.17-0.43). Respondents who suffered from chronic respiratory illnesses such as asthma were also more likely to feel that air pollution affected their illness (e.g. asthma affected by air pollution, OR 5.57 99% CI 2.27-13.68).

The survey found that proximity to industry and, to a lesser degree, having a chronic respiratory illness were the most significant factors affecting public views on how air quality affects the health of those living within a particular community.

Through in-depth interviews we were able to explore public perceptions of the risks to health from air pollution in more detail. All of the interviewees associated potential health risks with air pollution. As with the survey, the health risks identified were predominantly respiratory such as asthma and bronchitis although others included allergies, headaches, skin rash/eczema and colds. However, there were marked differences between interviewees living in Teesside and Sunderland when it came to views on the relative significance of air pollution as a factor affecting health in the district where they lived. A frequently recurring theme running throughout the interviews in Teesside was that there was a high incidence of chest complaints in the district and that - although other factors could also be important - industrial air pollution was likely to be the main contributing factor.

Views on air pollution as a factor affecting health in Teesside were very clearly inter-related with experiences of air pollution in the district. The interviewees often made graphic reference to the extended skyline of chimneys and to the orange haze, red clouds and mist which spatially demarcate the pollution boundaries of Teesside. Teesside respondents described how their district was immediately associated with industrial air pollution and chemicals by
those living outside the area. Some interviewees from Sunderland also talked about Teesside as a polluted place during their interviews. Our findings suggest that Teesside suffers from a stigmatised identity: ‘spoiled’ on the basis of industrial air pollution and ill-health. In Sunderland there was no association between air pollution and poor health at the level of the district as a whole. Goffman (1963) argues that “dis-crediting characteristics” are used to stigmatise one person whilst confirming the usualness of another. In our study, those from outside the district - in labelling Teesside as dirty and unhealthy - confirmed the usualness - in this case, the relative cleanliness and healthiness - of the place where they lived.

However, our analysis found that the stigma of industrial air pollution was applied not only at the level of Teesside as a whole, but also differentially within Teesside itself. We found that within Teesside, this stigma was applied to those who lived in communities closest to industry. Dis-association strategies were adopted by people living at a distance from industry, who argued that although air pollution was a problem in Teesside as a whole, it was not a problem in their particular community. In the two communities at a distance from industry in Teesside, air pollution was perceived to be a problem only for socially and geographically distant ‘others’. Geographical distance from industry, and images of the countryside and rurality were drawn on to emphasise ‘distance’ and difference.

Interviewees living in different communities tended to have different views on the relative significance of air pollution as a factor affecting health in the community where they lived. In Teesside, those living in the two communities at a distance from industry did not generally feel that the health of those living in their own community was affected by industrial air pollution. Interviewees from these communities tended to distance themselves from the health effects of industrial pollution by arguing that this was only a problem for those living close to heavy industry. So ‘dirty’ communities were also viewed as ‘unhealthy’ communities and these images reinforced each other.

In the community closest to heavy industry, residents often referred to air pollution as something that they could see, smell and touch. In this community many felt that ill-health - particularly respiratory conditions such as asthma and bronchitis - was largely attributable to industrial air pollution. Inflated percentages were sometimes used to support this belief. The association between air pollution and poor health in this community was also reflected in local sayings, such as “Even the sparrows round here cough”.

However, three important points must be made in order to contextualise views on how air quality affects health in the community close to heavy industry. Firstly, although all respondents in the community closest to heavy industry felt that industrial air pollution had a major effect on childhood asthma in the community as a whole, when asked about the main factors affecting their own or their child’s asthma, air pollution became less significant. For example, one respondent - after initially stating that 99.9% of children in her community suffered with asthma due to air pollution from surrounding industry - later described how her own son’s asthma had been worst when they’d been on holiday in the countryside. These findings appear to support those of the survey described earlier. When talking generally, the interviewees from the community closest to industry in Teesside felt that many people in their neighbourhood as a whole suffered from asthma and other illnesses affected by industrial air pollution. However, when talking about personal or family experience of asthma, air pollution diminished in significance and factors such as pollen, stress and non-industrial
forms of air pollution were more important. Community views thus sometimes conflicted with personal experience.

Secondly, the stigma of poor health in South Bank was contested. Some of the interviewees expressed resistance to what they believed to be an over-diagnosis of chest complaints in the district: that GPs were automatically diagnosing children with asthma just because they lived near to industry.

Thirdly, the stigma associated with communities living close to industry in Teesside was not only related to air pollution and ill-health but also social stigma. The literature has highlighted how communities who live close to polluting or potentially hazardous industries also often suffer high levels of unemployment, poverty and crime, producing what (Walker et al. 1998) have termed a 'faulty environment'. In Teesside the stigmas and images of air pollution, technologies and social stigma are strongly inter-linked as the communities close to industry have a long history of both industrial development and social-economic deprivation.

CONCLUSIONS
Our study found that public understandings of how air quality affects health draw, in particular, on personal experience and local knowledge and that these views are framed and negotiated in relation to the local, economic and cultural contexts of everyday life. We found that those who lived closest to industry, who experienced air pollution more frequently and more severely, were those most likely to attribute health problems in their communities to industrial air pollution.

Our study also highlighted substantial differences in the place identities of Teesside and Sunderland. Whilst both are essentially industrial regions, Teesside suffers from a stigmatised identity, ‘dis-credited’ (Goffman, 1963) on the basis of a range of attributes, encompassing not only stigmatised technologies (heavy industry and air pollution) but also poor health. This stigma is negotiated at a variety of spatial levels and strategies of ‘distancing’ and ‘shifting ownership’ are employed to ‘Other’ air pollution as a problem.

REFERENCES


DETERMINANTS OF EXPERT AND PUBLIC PERCEPTIONS OF RADIATION RISK

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This research examines the determinants of radiation risk perceptions for both experts and the general public. A questionnaire, developed from previous research, was administered to both health care workers who’s job involves the use of radiation and members of the public. The questionnaire concerned their risk estimates for 15 different radiation sources. The results indicated the public made greater risk estimates than the experts for all sources of radiation, with the exception of radon gas and medical x-rays. Further analysis was carried out to determine the dimensions along which the risk estimates were made. The results indicated that the public’s risk perceptions of radiation hazards are reducible to two dimensions: *dread* and *trust*, with artificial sources typically perceived as more hazardous. The experts, however, while sharing the *dread* dimension did not have a distinguishable trust factor but rather a unique dimension of *knowledge*. The differences between the groups’ risk estimates are explained as a function of the qualitative differences our research identifies in their risk perceptions.
TRACK 4

SESSION 1

DECISION MAKING UNDER UNCERTAINTY – LAND USE PLANNING
DETERMINANTS OF EXPERT AND PUBLIC PERCEPTIONS OF RADIATION RISK

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This research examines the determinants of radiation risk perception for both experts and the general public. A questionnaire, developed from previous research, was administered to 350 health care workers and 500 members of the public. The questionnaire contained items related to demographic and psychological radiation sources. The results indicated that the public made greater risk evaluations than the experts for all sources of radiation, with the exception of nuclear power and the use of X-rays. Further analysis was carried out to determine the determinants along which these risk estimates were made. The results indicated that the public's risk perception of radiation hazards are relatively less developed "theoretical" and "prescriptive" and that these perceptions are not significantly different from other groups. The major factor determining risk perception was the extent to which the public believed in the health hazards of radiation. This factor was more influential than other factors such as the public's knowledge of the risks, their exposure to radiation, or their occupational status.

DECISION MAKING UNDER UNCERTAINTY

LAND USE PLANNING -
EXPRESSING RISK AVERSION AND RISK PRONENESS IN LAND USE PLANNING

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ABSTRACT
Attitudes towards risk in decision making concerning Land Use Planning around hazardous chemical installations are examined. Risk proneness and risk aversion are incorporated into a methodology supporting relevant decisions and including multiple criteria and uncertainty. This is done through the concept of certainty equivalent. The approach is demonstrated in a realistic case.

1. LAND USE PLANNING AS A MULTICRITERIA DECISION PROBLEM
One way for managing the risk around chemical sites consists in limiting the possible consequences of a major accident by controlling the exposed population through appropriate land use planning. Member states in the European Union have recognized this fact and they have undertaken the obligation to develop such plans under the so called SEVESO II directive recently approved by the European Parliament and the European Council[1].
As the Land Use Planning problem touches a number of issues (human health, environment, economic growth) it is characterized by multiple conflicting objectives (attributes) and thus, it is considered as a multicriteria decision problem. A methodological approach drawing from the theory of MultiCriteria Decision Analysis (MCDA) has been developed to support the choice of land use patterns in the vicinity of major hazard facilities, when various alternatives compete with each other[2]. The main steps of the methodology are as follows.
The area under study is divided into a number of regions. Next, a set of alternative Land Development Types (LDTs) that can be applied to each and every region is defined. A Land Use Pattern (LUP) is defined when a unique LDT has been assigned to each region. The set of all the possible LUPs (the size of which depends both on the number of regions and the number of LDTs applicable to each one of them) constitutes the decision space of the problem. Next, a set of evaluation criteria that quantify the objectives of the decision at hand is defined. For each one of the alternatives (LUPs), a vector of values (one for each of the evaluation criteria used) is generated. This set of vectors constitutes the consequence space. The methodology uses the concept of dominance and the Efficient frontier to greatly reduce the size of the decision space[2,3,4]. The generation of the efficient frontier involves no value judgments in terms of value tradeoffs among various consequences. However, choice of any point of the efficient frontier as an "optimum one", explicitly or implicitly constitutes a value judgment. The efficient frontier can thus be divided into regions according to the value judgments implied. Examination of these regions can then facilitate the choice of the preferred solution.

2. EXPRESSING RISK AVERSION OR RISK PRONENESS
Associated with each alternative LUP are consequences that are characterized by uncertainties. A particular characteristic of the consequences is their possible high values associated with low probabilities of occurrence. Under such circumstances, risk measures like the expected number of
fatalities (potential loss of life) might not adequately represent the preference structure of the decision makers or the stakeholders. To investigate the possible effect of risk aversion or risk proneness, the developed methodology uses the concept of certainty equivalent. Component (one-dimensional) utility functions are defined for each evaluation criterion. Because of certain restrictions that apply to the methodology used to generate the efficient frontier\cite{4}, these component utility functions must be strategically equivalent to linear or exponential utility functions\cite{6}. Linear forms ($u(x) = x$) exhibit risk neutrality, while exponential forms ($u(x) = e^{\alpha x}$) express risk aversion for positive values of $\alpha$ and risk proneness for negative values of $\alpha$, where $x$ is any one of the criteria used (e.g. number of fatalities). For definitions of risk aversion, risk proneness, risk neutrality and the use of exponential utility functions, also see Ref. [4]. A certainty equivalent\cite{4} is then calculated for each criterion and for each region that the study area has been divided into, expressing the decision maker’s risk attitude and incorporating the uncertainties associated with the specific criterion. It is noteworthy that if the decision maker is risk neutral towards a criterion its certainty equivalent is equal to its expected (mean) value. The efficient frontier of the consequence space is then generated under the underlying assumption that the preference structure is such that the overall certainty equivalent for each criterion can be expressed as a linear function of the component certainty equivalents. Each point of this efficient frontier corresponds to a unique point in the decision space (a unique LUP). As mentioned above, omission of dominated solutions does not contain any assumptions about value tradeoffs among different criteria. This reduced set of alternatives can now be used as a basis for discussion or for the choice of the most preferred LUP.

3. THE CASE STUDY
To illustrate the developed methodology for Land Use Planning, a Greek Chemical site has been selected for which a complete Risk Analysis according to the SEVESO Directive requirements has been performed.

The site is a Refinery containing both flammable (hydrocarbons) and toxic (HF) substances. The quantitative risk assessment methodology used and the corresponding system of computer codes are described in Refs [6] and [7] respectively.

The study area has been divided into a number of “isorisk” regions, i.e. pieces of land that are characterised by the same level of individual risk. In each one of these regions three alternative LDTs were assigned, namely “No Land Development”, “Light Land Development” and “Full Land Development”, each one of them implying a different economic benefit and a different population density for each region.

The evaluation criteria that were used in this case study were i) the number of fatalities during plant’s lifetime and ii) the net economic benefit obtained by the development of the land. No uncertainties were taken into account for the economic benefit and, thus, no special attitudes towards this criterion were considered. On the other hand, calculation of the number of fatalities is directly connected to the calculation of the individual risk (probability of death owing to an accident in the hazardous facility under consideration). There are uncertainties associated both with the nature of the phenomenon (probability of death) as well as with the calculation of the individual risk itself. As a result, a decision maker may express a risk averse or risk prone attitude towards this criterion.

Several efficient frontiers have been produced varying from expressing very risk averse to very risk prone attitudes towards number of fatalities. Two of them (the “risk neutral” one along with a “risk averse” one, namely the one for a value of $\alpha$ equal to 0.01) are presented in Figure 1.

It is noteworthy that the “risk averse” efficient frontier is displaced towards higher health consequence values with respect to the “risk neutral” efficient frontier. This means that a given LUP (associated with a single value of benefit) corresponds to two different values of the health consequences depending on the risk attitude. For example the LUP shown in Figure 2a, implying a benefit of 1100 monetary units, corresponds to 3 fatalities for the risk neutral attitude while it corresponds to 4 fatalities for the risk averse attitude. On the other hand,
LUPs that are equivalent from the point of view of fatalities differ in their details as well as in the implied benefit, the “risk averse” attitude requiring more restrictive policies. For example,

![Figure 1. Two Efficient Frontiers](image)

Figures 2a and 2b show two LUPs (corresponding to points B and C of Figure 1, respectively) equivalent from the fatalities point of view. As mentioned above, the “risk averse” LUP is more restrictive than the “risk neutral” one, allowing less people to reside in the vicinity of the plant.

4. ACKNOWLEDGMENT
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5. REFERENCES

**Figure 2a. Land Use Pattern**

Legend

- Full Development
- Light Development
- No Development

**Figure 2b. Land Use Pattern**

corresponding to points A and B of Figure 1.

corresponding to point C of Figure 1.
APPLICATION OF ENVIRONMENTAL DAMAGE ASSESSMENT METHODOLOGIES TO RELEVANT RISK SITUATIONS CONSIDERED IN "SEVESO 2" EEC DIRECTIVE

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The paper takes into exam the substances defined as “dangerous for the environment”, bearing the following risk phrases:
- R50: Very toxic to aquatic organisms
- R51: Toxic to aquatic organisms
- R52: Harmful to aquatic organisms

And as introduced by EEC Directive 96/82 as dangerous substances capable of inducing major accident risks.

Such classification includes widespread matters, as diesel fuel and kerosene.

The analysis proposes to evaluate which modellistic approaches are best appropriate to assess accident scenarios, which in any case develop in complex ways, both in terms of extension of affected areas, and in terms of diversity of impact mechanisms.

It also aims to consider which parameters and standards are suitable to represent schematically damage limits, with particular reference to consequences being relevant for notification (as defined in Directive):
- Permanent and long term damage caused to earth habitat
- Permanent and long term damage caused to surface water or sea water habitat
- Relevant damage caused to ground water.
INTRODUCTION
Products from Chemical Industry are very common in everyday life, but their production, because of substances and processes involved, is often subjected to risk. These risks could have serious consequences in terms of human lives and economical losses; these factors not only have a great resonance on public opinion, but also induced to promote laws in order to improve safety and risk prevention.

To obtain these results, both qualitative and quantitative risk analysis are necessary, performed, for instance, by using risk definition as product between frequency of an event and magnitude of its consequences.

Quantification of risk also provides the possibility of risks comparison in order to perform a critical risk analysis and decide about risk acceptability.

RISK CALCULATION ASSUMPTIONS
First step for a quantitative risk analysis is choosing parameters for risk calculation. Risk is referred to as “area risk”, meaning with this term to perform risk calculation as sum of risk generated from each scenario related a predefined part of territory, so that a complete characterization of this area is obtained by splitting territory in basic square cells.

Each cell is represented by its center: every information or value is attributed to this point. Choose the optimum dimension for cells is necessary to compose two opposite requests:

• accuracy in representing variables changing;
• calculation rapidity and results storing capacity.

To do this, fixed dimension for the side of cells has been set to 10 meters.

Risk is referred to as:

• Local Risk: it is defined as probability of death for a person present in a particular point on the area, 24 hours a day, without protection or escape;
• Individual Risk: it is the frequency of a level of damage for a target exposed to an accident; we can assume that individual risk is defined from local risk including also probability of presence of the target;
• Societal Risk: relation between number of death (level of damage) and cumulative frequency (sum of frequencies of events that caused at least the predefined number of deaths).

Primary effects of scenarios in the area of interest for risk analysis are not homogeneous; we can group them in three classes:

• thermal radiation;
• overpressure;
• concentration of toxic substances.

To uniformate these kinds of scenarios, not primary effects are taken into account, but vulnerability of targets to these effects.

There are two ways to do this:

• using Probit functions (mathematical relation between primary effect of an accident and vulnerability of a specific target to these effects);
• using Sensitivity Indexes (limit value of primary effect for which an accident can cause a specific damage).

When possible we preferred Probit functions in order to increase accuracy; but because of Probit parameters are not always known, also Indexes way has been performed.

More than one Probit function is known by literature; so that a choice was made in order to compose information number, complexity and optimization of calculation time.

Associated calculation models permit to evaluate primary effects. Because of their dependency on atmospheric conditions (stability class, wind speed and direction) we considered:
• three stability classes (neutral, stable and unstable weather conditions) which reduces the number of Pasquill stability classes; for each class is assigned a typical wind speed.
• eight wind directions.

For each evaluation results are weighted with the probability of the related stability class and wind direction.

DEFINITION OF TOOLS AND INFORMATION

Computer aided calculations needs input data stored in a useful way. These data are not only in large number but also not homogeneous; for this reason we organized and structured them in order to obtain easy access and use.

A relational database system is the basis of data organization. This system is subdivided in five databases:
• Territory database: contains every information needed to build a geographical reference of examined area; this kind of information is generally available from cartographic sources. In this database are collected also meteorological and population data;
• Plant database: containing data about lay-outs, activities, safety and storages for industrial plant on territory;
• Substances database: with information about hazardous goods, their physical-chemical properties, behaviour and toxicity, needed for calculation models and vulnerability evaluation;
• Risk database: containing local, individual and societal risk evaluation and data for their presentation;
• Authorities/Institution database: with information about organisms responsible for emergencies control and management and their location on territory.

Each database is a collection of different tables in order to have an efficient data management.

RESULTS PRESENTATION

The goal of result presentation is to give all potential needed data, so that they can be easily and immediately available; the way naturally preferred is map presentation, by drawing risk contour (local and individual risk) on territory.

Map and tabular data, together, allow an immediate comparison between territory data and risk levels. This means that it is possible to find out:
• how many people are involved in accidents and which is their distribution on territory;
• where are industrial plants that can be sources of risks;
• which is hazardous goods distribution on territory;
• which are the available resources for rescue and emergency control.

Moreover F-N curves (Societal Risk) permit to know global impact of scenarios on territory so that it is possible to find out the most dangerous ones (in terms of number of deaths or frequencies).
In this way SITAR is presented as decisional support, giving the necessary data for risk management and territorial planning.

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FORECASTING AND CONTROL OF MARKET RISK IN REAL ESTATE INVESTMENTS

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ABSTRACT
The presence of risk and uncertainty components, linked to the stochastic nature of many variables we have to deal with, makes the phase of investment decision in production activities difficult, particularly in the real estate sector. In order to direct the investment decisions, it is possible to have recourse to the application of instruments to verify the financial profitability generated by the investment itself, for example the Cash-flow Analysis; this technique, however, must be intended according to the Probability Analysis interpretation, which overcomes the traditional deterministic model limits, permitting to introduce input variables value through their distributions, in an analytical sense. The focus of this paper is placed on the definition of the input variables of the Cash-flow Model, i.e. in the identification, according to the analytical approach, of their more suitable functional form. In particular way, the attention is placed on those variables whose uncertainty is strongly connected with temporal aspects, therefore to forecasting problems: for example, variables connected with the uncertainty in the building site timetable, or in the building work progress; the uncertainty linked to the products selling time (which, in absence of market analysis, makes the definition of a credible selling plan difficult). Starting from the fact that in the real estate sector in Italy is possible to point out the presence of sub-markets, strongly connected to own dynamics in demand and supply and, for this reason, to different levels of riskiness (market risk), the author present a case-study referred to a concrete context. The author reflects on the results of a Cash-flow Analysis application (resolved through simulation models like Monte Carlo Method or Latin Hypercube Sampling), including some critical variable in analytical form, taking eventually into account the correlation among the variables themselves.

1. MARKET RISK IN REAL ESTATE INVESTMENTS
This work is the continuation of a theoretic study -conducted with R.Curto- dealing with the evaluation of the financial profitability of investment projects affected by risk and uncertainty components1. In the previous study, the quantitative risk analysis was discussed with the probability analysis approach, according to the analytical method and the simulative method. In the present paper -step of a work still in progress- without going into the formal aspects of models, we refer to the simulative method (on the assumption that the data required for an analytical resolution would not be available) trying to reflect about some theoretic aspect previously treated against a concrete context of application.
Analysing financial investments - in the atypical case of real estate markets - consists in the application of theories and tools aimed at verifying the financial feasibility of individual investment proposals. In urban contexts like Turin (or other italian towns), these proposals often take the shape of investment projects - involving the transformation, re-qualification or reclamation of real estate - such as, for instance, new construction projects or overall restructuring activities. In many cases, these projects are located in transformation areas very different among them: even if it is considered negligible in many cases, the incidence of
market risk may however arise, in function of the time required to satisfy specific consumer demand. Starting from these assumptions, the case presented below is based on the mentioned areas, taking into consideration a hypothetical party who finances and builds a new residential project, in Turin. In reflecting about the project investment - and about the opportunity to finance the project in presence of profitability and risk acceptability thresholds established before- we keep in mind that results expressed in probabilistic terms are better suited in the decision. Data processing for the study was carried out using the software programme @Risk, ver. 3.1 for Windows (by Palisade Corp.).

2. SIMULATION

Simplifying here the main stages in which can be organized a simulation process, the first step in modeling the subject of the study involved the drafting of the financial time-table in spreadsheet form, following the logic and methods of Cash-flow Analysis (CFA). The input variables of the model represent the technical and operative aspects of the project and its execution, as well as financial factors (Table I). The unfoling of the following steps takes into account some general considerations that may appear: for example, the presence of stochastic variables; the limits of the deterministic version of CFA in the consideration of such variables, an issue already dealt with; in certain cases the input variables could be obtained from the application of other linear and non-linear models.

Critical variables - “allocating the distribution functions to the critical inputs of the cost-return table” stage- are attributed by replacing expected values with intervals of possible values, in function of the probability distributions that best approximate observed data. The selected output variables are: N.P.V. p.t. (Net Present Value, after tax on profits) I.R.R. (the annual Internal Rate of Return), FINANCIAL FLOW (the after tax financial flow after deduction of financial charges, for each of the 20 time periods that make up the total time span of the project). The second stage - “sampling and iteration”- was resolved using the stratified sampling method Latin Hypercube Sampling (LHS), assigning 300 iterations, 7 uncertain input variables and lastly, 22 output variables. The following data - “statistical calculations on the results” stage- were processed as output using some of the various functions available in @Risk: summary statistics with minimum, mean and maximum values, both for the sampled input distributions and the resulting output distributions; detail statistics, providing further statistics for individual variables (the percentile values at 5% intervals are particularly worthy of mention); sensitivity analysis, calculated in order to identify the input distributions that have the greatest impact of output values (carried out using stepwise regression analysis of which the R squared index is provided for each variable and rank correlation analysis, providing the Spearman rank correlation coefficient); scenario analysis, based on conditional median analysis that was used to identify variable groupings that were significant in reaching pre-set target values.

The sensitivity of the output to fluctuations in input values may be read, for each variable, in the statistics generated using the sensitivity analysis mentioned above. On the other hand, the logic of scenario analysis was used to identify groups of critical variables that have a stronger impact on the results, in terms of percentage thresholds (established earlier, for instance, on the basis of mean market trends) to be reached (“comparing the results with pre-determined target values” stage). Defined in this manner, this result seems more in keeping with the
context of our analysis. Demand in real estate markets in fact features a synergy between various factors that are not always “isolatable”, enriched by irrational elements that justify the willingness to pay that may, in some cases for instance, force solvency thresholds to the detriment of other consumer items while, at other times, favour the location of the buildings, regardless of other quality expectations.

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<td></td>
<td></td>
</tr>
<tr>
<td>IRR a.t. (annual)</td>
<td>3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cost taxation situation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N.P.V. p.t. (r = 4%)</td>
<td>0,985%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRR</td>
<td>2,374%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRR p.t. (annual) &gt; 10%</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Cash-flow Analysis. An example with stochastic input variables (first part of the spreadsheet).

For instance, in the case of the variable IRR, the group of critical variables that contribute to ensure that the results of the simulation fall within an pre-fixed target interval, such as, for instance IRR>90% (that is to say the variables that contribute to ensure that the results for IRR are greater than the 90% percentile), includes: flat selling price, land cost, the flat building cost and the incidence of financial charges, that is to say, interest payable (Table 2). The attainment of the pre-fixed goal - an IRR value of 17.22% - is therefore promoted by the occurrence of the values indicated for the group variables. It must however be noted that the calculation of the percentiles shows that at the 45% percentile, IRR reaches a result that is
acceptable when compared to the threshold established (indicated in the Table at 10%), when compared to a hypothetical IRR mean on other investments featuring similar duration and sector of investment.

Output Variable: I.R.R. p.t. (annual)/TOTAL
Cell F50
Target= >90%

Significant Input Variables for This Target

<table>
<thead>
<tr>
<th>Cell</th>
<th>Name</th>
<th>Percentile</th>
<th>Actual</th>
<th>Ratio Median to Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C25</td>
<td>flat selling / selling prices</td>
<td>92.33%</td>
<td>3773018</td>
<td>1.409359</td>
</tr>
<tr>
<td>C6</td>
<td>land / prices</td>
<td>86%</td>
<td>273529.5</td>
<td>1.151703</td>
</tr>
<tr>
<td>C16</td>
<td>flat building / prices</td>
<td>26%</td>
<td>1144154</td>
<td>-0.68143</td>
</tr>
<tr>
<td>A33</td>
<td>interests</td>
<td>29.67%</td>
<td>6.74%</td>
<td>-0.70991</td>
</tr>
</tbody>
</table>

Table 2: Example of scenario analysis: results for the input variable IRR. Conditional median analysis results for the target IRR> 90%.

A similar reading of the results of scenario analysis for the other output variables - results that may be rendered more explicative by the insertion of other target values distributed along the flows - it is possible to identify a “trend of influence” of the critical variables on the values calculated for output variables and all the points of the greatest concentration of risk.

In the absence of sure data on sales times, the interpretation of this information (also in graphical form - “graphic expression and interpretation of the output” stage) may help schedule the building site time-table to ensure that the goal - already pursued using project management techniques - of reducing the period of financial risk exposure, is reached, even in the context of corporate policies aimed at limiting supply prices and therefore controlling market risk.

3. CONSIDERATIONS FOR FUTURE WORK

Finally, it must be pointed out that the program collects not only the data calculated at each iteration, sampled from input distributions, but also the data calculated for output distributions. Simulation carried out on a previously discussed model reached a very high number of iterations, using the function for checking the convergence of results. On the basis of these observations, it is perhaps useful to wonder: besides serving as a basis for the most advanced deterministic analyses (sensitivity, scenarios), could these peculiar “databases” made up of simulated and not observed data, be used as a base of information for the application of other analysis techniques suited to the study of the real estate market, such as, for instance, Structural Equation Models (SEM)? It is in this direction that research based on the present work, will continue.

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Palisade Corp. (1995) @Risk, Advanced risk analysis for spreadsheets, User’s Guide.

7. See: J.P.C. Kleijnen and W.H. Von Groenendaal, quoted in the bibliography.
8. The variable LAND (land price expressed in Italian Lire per square metre) was bestowed with a triangular distribution function based on the parameters of lowest price, mean price and highest price (2,000,000, 2,500,000, 3,000,000), defined on the basis of the market price in Italian Lire per square metre of land surface area. The same applies to the variable FLAT BUILDING (flat building cost, in Italian Lire per square metre) that was subjected to triangular distribution (1,000,000, 1,200,000, 1,400,000), while the variable FLAT SELLING (flat selling price in Italian Lire per sq. m.) was subjected to normal distribution using the parameters of mean price and standard deviation (3,350,000, 300,000). The variables INTEREST (interest receivable and interest payable, expressed as percentages) were subjected to uniform distribution on the basis of the parameters of minimum price and maximum price (interest receivable : 0.02, 0.03; interest payable: 0.06, 0.085), as were the variables NPV r=4% (pre-tax (a.t.) and after tax (p.t.) discount rate) using the parameters 0.02 and 0.06. Furthermore, there is the possibility to recognize a correlation between the variables LAND and FLAT SELLING, since there is strong relation of dependence between the sales price of flats and the cost of the plot. It is a well-known fact that market values depends not only of the gross ground surface area available for construction, the uses to which the property may put, and therefore, the potential profitability of the real estate, but also on the location of the plot and the sub-market within which it falls, all of which are factors that affect real estate prices.
10. Given the FINANCIAL FLOW, it is possible to identify, for each time period, the degree of influence, for instance, of financial charges and taxes, the incidence of site costs, the percentile values at which the balance for each period is positive and more generally.
Table 2. Example of symptom analysis: reasons for the signs of anxiety (A1, A2, A3, A4, A5) followed by the targeted symptoms in the table.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Actual</th>
<th>Rate Matched in 100 Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table shows the rate of matches for different symptoms in 100 patients. The symptoms are divided into different categories, each with its actual rate and the rate matched in the patients. This table is an example of symptom analysis, which helps in identifying the targeted symptoms and the reasons for the signs of anxiety. The targeted symptoms in the table are A1, A2, A3, A4, and A5, which are followed by the targeted symptoms for the signs of anxiety.
TRACK 4

SESSION 2

DECISION MAKING UNDER UNCERTAINTY – APPLICATIONS
ASSESSING TRANSPORT SAFETY FROM MULTIPLE PERSPECTIVES

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ABSTRACT
Among others risk is one of the aspects to be assessed in case of developing transport infrastructures. Traditionally in transport infrastructure developments two often in isolation from each other assessed risk foci are used. Firstly, the policy field of infrastructure operations focuses on internal or passenger safety, using the expected annual number of fatalities among passengers as a risk indicator. Secondly, the policy field of spatial planning focuses on external or third party safety, using individual and group risk as risk indicators. Examinations of transport safety assessments revealed that mentioned risk indicators do not obviously discriminate among transport infrastructure alternatives at hand. Examinations of related decision making processes revealed that in addition to infrastructure owners and spatial planners, emergency response organizations have their own transport safety information needs focussing on infrastructures' accessibility.

As a result of both the examinations of transport safety assessments and related decision making processes, an approach is introduced that reckons for alternatives to be evaluated during transport infrastructure development and public policy fields involved. Alternatives include mode, corridor and design evaluations of transport infrastructures. Policy fields concern infrastructure operations, spatial planning and emergency response. A set of safety and risk indicators is developed to match policy fields' safety information needs thereby reckoning for alternatives to be evaluated during the transport infrastructure development.

INTRODUCTION TO INFRASTRUCTURE DEVELOPMENT
Numerous authors described step-wise procedures to develop transport infrastructures [Pickels and Wiley, 1939, Skelton, 1949, Scott, 1965, Meyer and Gibson, 1969, Hay, 1982, Psarianos, 1982, Linden, 1989]. From a safety perspective two remarks are important with respect to such procedures. Firstly, starting point of most procedures is that the transport mode is fixed. Only Meyer and Gibson [1969] and Linden [1989] include the evaluation of various transport modes in their transport infrastructure procedures. From a safety perspective evaluating transport modes is important because transport modes can already to a larger extent determine final safety levels. Secondly, all procedures include corridor options however some exclude design options [Pickels and Wiley, 1939, Skelton, 1949, Scott, 1965, Meyer and Gibson, 1969]. Design options are important too from a safety perspective because they may influence accident scenarios, frequencies and consequences. Therefore, transport safety needs to be considered in respect to evaluating transport modes, corridors and designs. Linden [1989] has described these three evaluation aspects:

- Systems planning; the most general level and a first analysis of a wide spectrum of issues in relation to possible alternative solutions with regard to different modes of transportation,
- Corridor planning; the identification of alternative zones for a chosen transportation mode,
- Design; in a fixed study area only minor shifts in the allocation of alignment location will occur and emphasis is placed on matters of engineering design.
Because transport safety relates to transport modes, corridor alternatives and designs options, Linden’s steps should not be considered in isolation from each other, but moreover in connection. Two levels of detail seem fruitful for generating safety information. Firstly, a general level including mode/corridor assessment in which transport safety can already be assessed using transport mode and corridor information. Transport modes give insights in expected transport flow (people and goods), necessary number lanes/tracks, accident frequencies and possible fatalities per accident. Corridor options give insights in infrastructure length, third-parties in residential areas, topographical aspects and traffic compositions. Secondly, a more detailed level including design assessment in which design options add relevant information to mode/corridor combinations such as deeper insights in design related accident scenarios, frequencies, and consequences.

SAFETY INFORMATION NEEDS AND RELATED TRANSPORT SAFETY INDICATORS
Numerous policy fields play a role in infrastructure decision making [V&W, 1998]. However, only few of them are primarily interested in transport safety issues. The in transport safety interested policy fields are related with certain categories of transport accident victims (called party-victims by Perrow, 1984). The party-victims as a result of transportation accidents can be related to three policy fields acting in transport safety and infrastructure decision making. Firstly, the policy field of infrastructure operations deals with operating and controlling transport movements, and therefore with the safety of people within transport infrastructures boundaries (Perrow’s first and second-party victims). Secondly, the policy field of spatial development is concerned with protecting zones next to transport infrastructures for external effects and therefore with the safety of people in transport infrastructure surroundings (Perrow’s third-party victims). Thirdly, the policy field of emergency response deals with fighting accident consequences and as a result with the safety of emergency responders (here called fifth-party victims). Perrow’s fourth-party victims are omitted for reasons of vague relationships between accidents and fourth-party victims. The three distinguished policy fields will have their particular safety information needs when transport infrastructure is to be developed. Counting for available information, safety indicators are developed for assessing mode/corridor and design options. In this paper, prime focus is on mode/corridor safety assessment.

INFRASTRUCTURE OPERATIONS
Safety of first and second-party victims can be expressed in expected number of fatalities or injures per year. However, this expected number (μ) is just a number which does not give good insights in spread (σ) and distribution of fatalities. The spread and distribution of fatalities provide relevant information for the robustness (confidence level α) of the expected number of fatalities and ranges for which this number may vary. Therefore, a risk profile is proposed. At the stage of evaluating mode/corridor combinations, the starting point for developing risk profiles is the generally available information in such early development stages such as transport volume of people and goods. Moreover the following transport mode related safety information is available: necessary number of lanes/track, general accident frequencies and fatalities per accident. Related to corridor options information about topographical aspects, traffic composition and length is available. Risk profiles should be developed using as much as reasonable real-life accident data. To gather real life data, the complete corridor should be divided in homogenous corridor segments. Within a segment transport flow, number of lanes, topographical aspects, traffic composition are the same. Per corridor segment, accident databases are searched for similar segments for which accident...
data are available. Differences in length between database segment and assessed corridor segment and differences in accident database period and corridor segment period to be assessed should be rectified. Evaluating design options demands for accident data or expert opinions specified for particular design options. However, different design options will not adjust to a large extent the already generated mode/corridor risk profiles.

SPATIAL DEVELOPMENT
Today, safety of third-party victims is assessed using individual risk and group risk. Individual risk (IR) is the chance-per-year that a person will experience certain harmful effects as a result of exposure to an agent (expressed in chance-units per year or related to an average concentration per year). Group risk (GR) is the chance-per-year that a group of a certain number of people will be seriously injured or killed, at one and the same time, as a result of one accident [VROM, 1989]. Necessary data to evaluate mode/corridor options are the hazardous materials transport flow, accident frequencies, dispersion models and dose-response relationships. In addition to necessary individual risk data, to calculate group risk, the position and number of people present in the transport infrastructure surrounding is to be known. Group risk is calculated for one-kilometer segments of a corridor. To evaluate a corridor as whole, the expected group risk seems useful, which in fact is the sum of all the one-kilometer segment’s expected group risks. Evaluating design options moreover demands for adjusting dispersion models according to design characteristics.

EMERGENCY RESPONSE
Fifth-party victims (emergency responders) as a result of transport accidents are rare. However, emergency response organizations have in addition other relevant safety needs. To evaluate mode/corridor combination, their first information need is insight in possible transport accidents that could occur and which they then have to mitigate. Both first, second and third-party victims are relevant to emergency response organizations. Therefore accident scenarios concerning the already mentioned parties should be developed. Accident databases can fulfill a useful role in generating accident scenarios. Emergency response organizations' second information need when evaluating mode/corridor combinations is the time necessary to get to accident spots. Corridor options in combination with fire stations and hospital locations indicate emergency response vehicle paths and thus driving distances. Applying speed averages enables estimating driving times. Evaluating design options asks for design specific accident scenarios and for the time it will costs emergency responders to walk from their vehicles to accident spots. Because emergency response vehicles may not be able to park next to accident spots, emergency responders have to walk, crossing barriers in transport infrastructure surroundings and transport infrastructures themselves. Field measurements and surveys have been conducted to quantify times to take such barriers.

CASE-STUDY
To verify the practical use of proposed safety indicators a hypothetical case study was developed [Rosmuller and Beroggi, 1999]. The most important elements of this case study are: a daily flow of 150,000 people, an annual transport volume of about 100 tons of chlorine, LPG and about gasoline. A new large-scale infrastructure connection for transport of both people and goods has to be constructed to accommodate this supposed transport volume. A two-lane highway and a four-lane railway are feasible transport modes. A north, middle and south corridor are feasible corridor. Thus, six alternatives are to be assessed using the above described safety indicators. Here, the indicators described are only applied to the highway/south alternative. This highway/south alternative consists of two segments, a rural segment (km 0-45) and an industrial segment (km 45-85). The highway crosses
several residential area (shaded blocks) with differing people densities per 100 square meters (numbers in blocks) as visualized in figure 1 below.

Figure 1: Highway/south corridor.

RISK PROFILE
As to the rural segment, a Dutch highway 15 segment (km 25-40) was selected. For the industrial segment a Dutch highway 20 segment (km 45-65) was used. Of both segments, accident data from 1990-1998 are used. As a result, 120 kilometeryear accident data of highway 15 are available and 160 kilometeryear accident data highway 20. These kilometeryear amounts were adjusted for the needed 45 kilometeryear (rural segment) respectively 40 kilometeryear (industrial segment). A bootstrap technique is used to combine both basic data sets to generate the risk profile as shown in figure 2.

Figure 2: Accident data and risk profile.

INDIVIDUAL RISK AND GROUP RISK
As to the industrial segment a bigger hazardous materials transport flow (+ 10 %) is expected because of heavy industrial activities. Using the IPORBM software (IPORBM is a software tool commissioned by Dutch ministries of transport and spatial planning). Transport volumes per hazardous materials as well as people densities in highway/south surroundings were imported. The software calculates individual risk distances and group risk curves per kilometer. The single group risk curves were combined to one F(n)-curve for the rural and one
F(n)-curve for the industrial area. We also calculated the expected group risks for both segments. The results are shown in figure 3.

![Figure 3: Individual risk $1E-06$ contour (IR), group risk (F(n)) and expected value of group risk (E(n)).](image)

**ACCIDENT SCENARIOS AND ACCESSIBILITY TIME**

Using the same accident database as for generating risk profiles, we selected a "head-tail collision with 2 injuries among 1 serious injured person being stuck in the car" as a useful most credible accident scenario. This type of accident namely occurred relatively often and demands both fire fighting and ambulance application.

Accessibility time is related to fire stations locations in respect to the corridor. Most of the fire stations are located outside the visualized residential area of the south corridor. Counting for road characteristics and vehicle speed, the driving time for fire fighting vehicles along the south corridor is as visualized in figure 4.

![Figure 4: Driving time.](image)

**FURTHER RESEARCH ACTIVITIES**

In this paper safety indicators were presented as to only assess safety of transport infrastructure alternatives from multiple perspectives. Another important aspect in evaluating transport infrastructure alternatives from multiple perspectives is to unite various safety
evaluations to one or some fruitful alternatives, supported by all three policy fields involved. In addition to sound safety indicators, this aspects asks for a well-defined assessment process in which safety indicators should facilitate a dialogue between various policy fields. This methodology has been developed and applied by Rosmuller and Beroggi [1999]. In a session based upon a self-developed case study, real-life public decision-makers and safety experts had to evaluate both mode/corridor and design alternatives.

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OPTIMAL BREAKWATER DESIGN FOR THE ROTTERDAM HARBOUR EXTENSION

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ABSTRACT
A tool for risk-based optimisation for caisson breakwaters is applied for the design of a breakwater protecting a land reclamation for the Port of Rotterdam. On the basis of the optimisation, adaptations of the design are proposed which lead primarily to a reduction of the risk. Analysis shows that the failure probability of the breakwater is decided by the hydraulic boundary conditions.

INTRODUCTION

The Port of Rotterdam is one of Europe's main ports. Due to economic development and growth of the harbour, it is expected that the existing harbour area will become insufficient in the beginning of the 21st century. For this reason, the Ministry of Transport, Public Works and Water Management in close cooperation with the Port of Rotterdam is planning a land reclamation project to extend the harbour into the North Sea. In conjuction with the existing reclaimed area (the Maasvlakte), the new area is called Maasvlakte 2. The newly reclaimed area will be used for the development of new harbour basins and associated terrains.

Several alternative lay-outs of the reclaimed area are under study. In most alternatives, the extension leads to a longer entrance channel. This entrance needs to be protected from wave action. Furthermore, the entrance channels to the new harbour basins also need to be protected. Thus, the extension leads to a substantial lengthening of the existing Northern breakwater. Several breakwater concepts are under study for the lengthening of the North Dam. One of the alternatives is the monolithic caisson breakwater. A conceptual design for such a breakwater is made by the design team "Maasvlakte 2 Alternatives". Risk-based optimisation is applied to adapt the design to the economic and environmental boundary conditions of the site.

In the remainder of this paper, first the concept of risk-based optimisation is introduced, followed by a description of the models used for the case at hand. Finally, an overview of the results is given.
Risk-based optimisation of caisson breakwaters

The concept of Risk-based optimisation for Civil Engineering Structures is introduced by Van Dantzig (1956). This first application was the optimisation of the safety level of one of the dikes protecting the economic heart of the Netherlands. Several years later, Van de Kreeke and Paape (1964) used risk-based optimisation for the design of the breakwaters of the first extension of the Port of Rotterdam (Maasvlakte).

Recently, Voortman et al (1998) developed a tool for the optimisation of caisson breakwaters. The basis of this tool is, as it is in all other applications, the function describing the lifetime costs of the breakwater. The lifetime costs of the breakwater consist of the initial investment in the breakwater and the capitalised risk over the lifetime, both as a function of three geometrical parameters of the breakwater; In formula:

\[ C(z) = C_{f,0} + C_f(z) + \sum_{n=1}^{N} \frac{365(P_{F,scen1}(z)C_{scen1} + P_{F,scen2}(z)(C_{scen2} - C_{scen1})) + P_{F,scen3}C_{scen3}}{(1 + r^r - g)^n} \]

In which:

- \( C_{f,0} \): Fixed investment;
- \( C_f(z) \): Investment as a function of design variables;
- \( P_{F,scen1}, P_{F,scen2} \): Failure probabilities per day of scenario 1 and 2 (see below);
- \( P_{F,scen3} \): Failure probability per year of scenario 3 (see below);
- \( C_{scen1} \): Damage in case of occurrence of scenario 1;
- \( N \): Lifetime of the structure in years;
- \( r^r \): Net interest rate;
- \( g \): Rate of economic growth.

In this description of the lifetime costs, risk is defined as the expected value of the damage in one year, which equals the damage in case of failure multiplied by the failure probability. This description is fully consistent with Van Dantzig. Minimisation of the lifetime costs leads to the optimal breakwater dimensions and, since the failure probability is a function of these dimensions, to the economic optimal failure probability as well. When in case of failure loss of human lives is important, the safety of people imposes a lower bound on the acceptable failure probability (Vrijling et al, 1995). However, the design of the North Dam is such that loss of human lives may be neglected.

FAILURE SCENARIOS

The main function of the North Dam is protection of the quay and the entrance from excessive wave action. In principle, the breakwater can fail to fulfill this function in two ways:

- The breakwater remains intact, but wave energy passes the breakwater causing inadmissible wave action in the entrance or at the quay leading to downtime (serviceability limit states);
- The breakwater loses its integrity. This leads to a breach which allows more wave energy to pass than the original geometry (ultimate limit state). Repair of the breakwater may take considerable time, leading to extra occurrences of intranquillity in the harbour during the time of repair.

The requirements for basin tranquillity are coupled to the occurring significant wave height in the harbour basin. Usually, the operations at the quay are more sensitive to wave action than the operations in the entrance channel. Therefore, in the study two failure scenarios for basin tranquillity are discerned. A third scenario describes loss of integrity of the breakwater.
Figure 2: Event tree for the North dam; three scenarios

The damage in monetary terms as well as the probability of occurrence is different for the three failure scenarios. Therefore, all three scenarios are included in the risk part of the lifetime costs. Based on data of the throughput of the harbour and estimates of the traffic in the new harbour area and the entrance, the damage for scenario 1 and 2 is estimated. The same data and estimates of the repair costs of the breakwater are used to derive the damage for scenario 3. An overview of the results is shown in the table below.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Unit</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Euro/day</td>
<td>570,000</td>
</tr>
<tr>
<td>2</td>
<td>Euro/day</td>
<td>2,669,000</td>
</tr>
<tr>
<td>3</td>
<td>Euro/event</td>
<td>74,400,000</td>
</tr>
</tbody>
</table>

BOUNDARY CONDITIONS
The probability of occurrence of scenario 1 or 2 is, apart from the breakwater geometry, a function of the daily occurring hydraulic boundary conditions on the sea side of the breakwater. In scenario 3, the loading is determined by the yearly hydraulic conditions, and the strength is primarily decided by the weight of the caisson and the strength of the subsoil. In shallow seas, extreme values of water levels and wave heights are strongly coupled, since they are both decided by the wind speed and wind direction. This is especially relevant for the yearly hydraulic conditions. The yearly conditions are described by a set of parametric models and distribution functions, together describing the simultaneous distribution of water level, significant wave height and wave peak period.

RESULTS OF THE OPTIMISATION
The optimisation of the breakwater design shows that considerable adaptations of the design appear to be necessary in order to derive an optimal design (figure 3).
Figure 3: The optimal breakwater design (dotted line: original caisson design)

The failure probability of the optimised design equals $3.6 \times 10^{-3}$ per year for caisson stability. Furthermore, the probability of serviceability failure is negligible for the optimised design. The investment appears to be virtually equal to the investment in the original design, but the probability of occurrence of scenario 3 is lowered one order of magnitude, leading to a reduction of the risk. An inspection of the normalised gradients of the reliability functions for caisson stability shows that the hydraulic boundary conditions virtually decide the failure probability. The sum of the influence factors of the hydraulic boundary conditions equals 85%.

CONCLUSIONS
This study shows that risk-based optimisation is readily applicable to breakwater design related to harbour protection. A rational choice for the acceptable safety level can be made, while at the same time the geometry corresponding to such a safety level is derived.

ACKNOWLEDGEMENTS
The optimisation tool for caisson breakwaters is developed by Delft University of Technology in the framework of the EU MAST-program PROVERBS under contract MAS3-CT95-0041. The optimisation of the North Dam was carried out for the design team "Maasvlakte 2 alternatives" under contract MMOC016.

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HARMONIZING APPROACHES TO DETERMINING DATA-DERIVED UNCERTAINTY FACTORS: BORIC ACID AS A CASE STUDY

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To account for the various types of uncertainty associated with setting chemical exposure levels thought to be without appreciable risk to humans, exposure levels observed to produce adverse effects are divided by several uncertainty factors, usually in multiples of 10. However, there is growing support for the use of data-derived uncertainty factors in health risk assessment when appropriate data are available. Methods for quantifying data-derived uncertainty values are not universally accepted and may vary in practice.

Boric acid provides an interesting case study of the varying applications of data-derived uncertainty factors because several well-respected organizations (including WHO Drinking Water Group, International Programme for Chemical Safety, Institute for Evaluating Health Risks, and ECETOC) have recently conducted risk assessments of this chemical, using virtually the same scientific database. A focal issue in the selection of data-derived uncertainty factors for boric acid is pharmacokinetics. However, different risk assessments use different approaches to select uncertainty factors to account for pharmacokinetic variation for boric acid. Boric acid is rapidly and almost completely absorbed orally, distributed throughout body water, and not metabolized in laboratory rodents or humans. As such, a major determinant of pharmacokinetic variation is the renal clearance rate. This variation is likely to account for both interspecies and intraspecies pharmacokinetic differences. Although it is readily acknowledged that pharmacokinetic uncertainty factors less than 10 are scientifically justified, there is no consensus on which factors are appropriate. The different approaches that have been used for boric acid will be compared and contrasted.

For boric acid in particular and for chemical exposures in general, additional discussion and analysis is needed to ensure that data-derived uncertainty factors are determined and applied in a consistent manner.
INVESTING WITHOUT KNOWING:
A SURVEY ON HOW A RESEARCH FUND MAKES DECISIONS
UNDER HIGH UNCERTAINTY*

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3 † 1998

A research fund is faced with difficult investment decisions. It has to avoid supporting incompetent applicants as well as falling victim to phonies or even swindlers. The paper presents an empirical analysis of this decision-making process. It shows that the research fund bases its final decisions on just four categories of information, three of which allow the fund to evaluate project applications and applicants in their respective social context.

YOU DON’T WANT TO BE TRICKED, DO YOU?
Imagine you are a member of a research fund’s decision-making body. Your organization receives some 800 funding applications a year, all of which euphorically describe new, challenging, and innovative research projects submitted by brilliant, committed people bound for success. Now it is your turn; you have to decide on where the research fund should invest its money.

Uncertainty is overwhelming. How do you go about it? Most certainly you will start with establishing a system of standards and regulations to be able to rule out applications right away which do not fit the research fund’s objectives. You will also call upon various experts who are capable of evaluating the project applications in great detail. They will help you to get rid of projects which at first or second view seem to have some flaws.

No doubt, standards and expert opinions improve the terms of your decision-making significantly. However, you are still faced with some extremely difficult issues. How do you filter out dreamers who are quite capable of drafting “wonderful” project descriptions but who won’t bring in the promised results? And worth still, how do you avoid falling victim to clever swindlers who present phony applications but won’t even try to deliver results?

These are the questions we are addressing with this paper. We do so by presenting a close—and we hope accurate—analysis of how long standing professionals actually make decisions in situations like the one we just described. (We do not attempt to instruct on how to make such decisions in the most rational manner.)

RESEARCH DESIGN AND RESULTS
The paper presents an empirical study of decision-making processes at Austria’s leading research fund for applied research and product development. At the time the study was conducted the fund managed roughly three quarters of all public funding for commercial innovations in Austria. The fund supports projects with up to 50% of their total costs by granting either subsidies or loans.
The fund's decision-making is based on two expert opinions, one supplied by a technical expert, the other by a commercial expert. Each expert is in the position to turn down an application independently. The research fund approves project applications that are supported by both expert opinions. Usually this standard decision-making process takes less than two months. Only few decisions are passed on to the fund's presidency, if after a lengthy debate the experts have difficulties with coming to a final decision—presumably due to higher than usual levels of uncertainty. It is these "passed on" decisions under extreme uncertainty we are interested in.

Our study re-examines 24 such decision-making processes: In nine cases project applications were turned down by the presidency; in twelve cases the presidency approved the project applications and subsequently funded the projects; in three cases the projects were approved but could not be funded due to budgetary restraints. These three latter cases closely resemble the twelve approvals in all other aspects. We therefore handle them as approvals (and not as polite rejections).

To learn how the fund's presidency makes its decisions, we compare what we know about the applications which got rejected (n = 9 rejections) to what we know about the applications which the fund's presidency finally approved (n = 15 approvals).

We base our analysis on 48 standardized interviews: 24 with the technical experts and another 24 with the commercial experts who earlier had evaluated the respective project applications. (For the complete interview schedule see Strommer 1995.) In the interviews both the applicants and their projects were assessed by the respective fund's experts in 21 different issues. This way we gain 42 assessments per project application (21 by the commercial experts plus 21 by the technical experts). We use U-tests to provide a quantitative measurement of the differences between rejections and approvals concerning each of these 42 assessments (which we interpret as independent variables). This allows us to test hypotheses on whether a specific independent variable influences the decision-making processes of the research fund's presidency (which we interpret as dependent variable).

The results of these tests come as a surprise. The rejected project applications differ on merely seven points from the projects which got approved (see the table below).

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant's competence, assessed by commercial experts</td>
<td>0.0028</td>
</tr>
<tr>
<td>Applicant's efficiency, assessed by commercial experts</td>
<td>0.0115</td>
</tr>
<tr>
<td>Relevance of project for market, assessed by technical experts</td>
<td>0.0232</td>
</tr>
<tr>
<td>Orientation of project towards future, assessed by technical experts</td>
<td>0.0235</td>
</tr>
<tr>
<td>Applicant's support by allies, assessed by commercial experts</td>
<td>0.0035</td>
</tr>
<tr>
<td>Applicant's future in industry, assessed by commercial experts</td>
<td>0.0146</td>
</tr>
<tr>
<td>Applicant's future in industry, assessed by technical experts</td>
<td>0.0135</td>
</tr>
</tbody>
</table>

What can we learn from the results so far? Even though the members of research fund's presidency have to make some particularly difficult decisions under high uncertainty, they seem to base their decisions on a very limited amount of information—on much less information than they have readily available. Of course a critic could reply to this as just missing many relevant issues by asking the wrong type of questions in the interviews.
So how much do the seven variables combined, influence the decision-making processes of the fund’s presidency? There is no way to give a precise answer to this question, due to the type of data we use. However a discriminant analysis can give us a rough idea. A discriminant function calculated from the seven variables is capable of classifying over 90% of the project applications correctly as rejections or approvals. From this, we may conclude that indeed the seven variables combined seem to have a major influence on the presidency’s decisions. In other words, our survey seems to pretty much capture the relevant aspects of the decision-making processes (under extreme uncertainty) we intend to analyze.

We believe that the decision-making processes of the research fund’s presidency can be represented most clearly by four sets of questions which are deducted from the seven independent variables.

**IS THE APPLICANT COMMERCIALLY SKILLED AND EFFICIENT?**

Let us begin with the two most obvious points: The applicant’s competence and efficiency. For good reasons a research fund tries to avoid investing money into projects which are managed by incompetent or inefficient people. Both the commercial and the technical experts were asked: Is the applicant competent? [1] And: Is the applicant capable of delivering results? [2] However it seem to be the commercial skills only which influence the presidency’s decision-making. (We assume that the commercial experts assess mainly the commercial skills of an applicant.) The assessments of the technical experts concerning competence and efficiency do not influence the presidency’s decisions.

Presumably the fund is able to reliably filter out applicants who lack the necessary technical skills early in its decision-making process. The assessment of a person’s commercial skills—especially if it has to be based solely on project applications—is connected with much more uncertainty. Therefore this issue is passed on frequently to the presidency.

**Does the project matter?**

**Is somebody waiting for the results?**

**Is it orientated towards the future? Or is just a hobby?**

The first two variables tell something about skills which are necessary to manage applied research and product development projects successfully. The remaining five variables work differently. They enable the fund to assess the applications in a social context.

Why does the social context matter so much? It works like a stick for blind people, helping us enormously to understand what is actually going on. We humans do not generally do particularly well when it comes to making risky decisions in complex and uncertain situations (Dörner 1996). However our abilities improve dramatically once we can see decisions in their social context (Cosmides & Tooby 1995, Eschenbach 1999a).

The research fund tries its best to avoid falling victim to dreamers or even swindlers. Therefore it makes sense to take information into account on whether a research project is directed towards the problems and needs of potential customers or if it just serves to satisfy the curiosity of the applicant. Concerning this point the decisions of the fund’s presidency seem to be influenced by the technical expert’s assessments. Our questions were: “How relevant is the project? Is it useful for somebody?” [3] And: “Is the project orientated towards the future?” [4]
Can the applicant count on the support of allies?
Will somebody help him or her in times of crises?

The next variable which makes a difference is the assessment of the commercial experts on whether the applicant can count on the support of allies. The experts were asked: “Has the applicant supporters outside of his or her organization?” [5] Again this variable helps to evaluate a research project in its social context.

For instance, a strong working relationship with a reliable bank (Eschenbach 1999b, Pelzmann 1985), the support of influential politicians or even the good accord with important civil servants can be vital for the success of a demanding research project, because they can help to ride out crises which will almost inevitably come up.

Will the applicant survive in business?
Can we do business with him or her again?

The two remaining variables assess the applicants future prospects in business—not concerning the research project in question but in a more general way. The fund prefers to work with people who are in an industry to stay, even if the current research project should flop. The experts were asked: “For how long will the applicant be in the respective industry?” [6] On this issue the fund’s presidency seems to take into account the opinions of both the technical and the commercial expert.

Robert Axelrod (1984) shows us why this makes sense. In his famous book “The Evolution of Cooperation” he demonstrates with the help of dynamic game theory that a stable future is the single most important condition for cooperation to evolve. Stability does not guarantee cooperation; but if a person is confronted with ever changing partners the temptation to misbehave is huge. Under such circumstances “hit and run” becomes the most profitable strategy. It seems, the research fund tries to avoid this by preferring applicants with a stable future.

ACKNOWLEDGMENT AND NOTES
* We thank the Forschungsförderungsfonds für die gewerbliche Wirtschaft (FFF) for granting Franz Strommer interviews about issues which are usually kept strictly confidential. Only the frankness and open-mindedness of the FFF made it possible to conduct this research project on investment decisions under extreme uncertainty.
1 The interviews were conducted in German. The original question is: “Ist er (der Antragsteller) kompetent?”
2 “Erzielt er (der Antragsteller) Resultate?”
4 “Reicht sein (des Antragstellers) Projekt weit in die Zukunft?”
5 “Hat er (der Antragsteller) Rückhalt außerhalb der Firma? Wer steht hinter ihm?”
6 “Wie lange wird er noch in diesem Geschäft sein?”
REFERENCES
EX ANTE RISK EVALUATION IN TRANSPORT DECISION MAKING

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The paper deals with some topics from the Ph.D.-research project of the author, which concerns the deliberate consideration of safety aspects and risks in decision making on transport infrastructure in the Netherlands. The paper roughly consists of two parts. The first part deals with the current practice of transport decision making and the role of risks and safety aspects therein. While describing this practice and its shortcomings the paper deals with the question:

* Is there a need for (new kinds of) ex ante risk evaluation? Changing and new risks and risk-perceptions as well as characteristics of the decision making process contribute to the growing need for a new risk approach. The second part of the paper looks at the future and examines the question:

* What kind of (decision making) instrument can meet the need for (new kinds of) ex ante risk evaluation?

* What kind of instrument does right to the characteristics of the decision making process as well as the risks involved in complex transportation systems?
DETECTION MAKING IN EXPLORATION FOR OIL AND GAS UNDER UNCERTAINTY

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ABSTRACT
Conventional planning concepts that are used in the manufacturing type of planning cannot be directly applied to exploration planning. In the second case it is necessary to examine and quantify risks of exploration programs. At the beginning of drilling of a well future result can be predicted only with some probability. At that time, while drilling is going on, it is necessary to make decision about subsequent actions. This is very hard to do because of the lack of full information about geological parameters of deposit. Any mistaken decision made in this situation can result in significant future loss. Because of restriction of capital spending, it is necessary for management to possess tools to analyze future exploration efforts. This paper presents such an approach that allows management (1) to generate future exploration opportunities utilizing available information in form of mathematical deposit model, and (2) to compare sets of exploration opportunities, thereby maximizing the effectiveness of capital allocations.

1. INTRODUCTION
Management of exploration program involves selection of projects of wells to be drilled. Main goals of the management are to increase the company reserve base and balance between return and risk. To reduce the probability of a loss a Decision Maker should make choice of positive expected value project of wells. On the other hand, to increase the return high expected value project must be selected. Typically, investments with high expected return carry with them higher risk. The choice of risk level should be complied with corporate strategic goals and objectives. After risk level has been fixed, the main attention should be paid to risk analysis and control. Since decisions on resources allocation must be made before an adequate assessment of the uncertainties is possible, it is desirable that Decision Makers have appropriate tool which would allow: (1) to generate future exploration opportunities utilizing available information in form of mathematical deposit model, and (2) to compare sets of exploration opportunities, thereby maximizing the effectiveness of capital allocations.

The purpose of this paper is to present an approach that meets requirements mentioned above. The proposed approach provides a framework for computer simulation of multi-step process of test wells allocation within a field that has been already discovered. Given the state of the exploration of an arbitrary discovered field this tool enables Decision Maker to determine minimal number of subsequent steps required to explore the field with the given level of uncertainty; the minimal number of test wells which should be initiated at each step; their optimal allocation and optimal order in which the wells should be drilled. The efficiency of capital allocations is expressed in form of expected value of reserves per unit of the exploration drilling. The tool can be readily extended to the cases of another efficiency criteria, such as the probability of the event that the amount of reserves per unit of the exploration drilling will exceed the given level. It is based on successive computer simulation.
of states of the exploration at each subsequent step by evaluating impact of possible outcomes of test wells drilled at previous step on the state at the next step.

2. MODEL OF THE EXPLORATION PROCESS
Exploration process can be modeled by a multi-step probabilistic game between the Decision Maker and the Nature. During this game at each step each participant makes by turns its choice. The choice of the Decision Maker consists of a number and allocation of future test wells; the choice of the Nature consists of geological parameters as outcomes of the test wells selected by the Decision Maker at the same step. Since the number of geological parameters which are determined during trial of a test well is large enough, it is convenient to operate with the value that depends on them. Therefore we shall assume that the choice of the Nature is a reserves density that is the amount of oil and gas per unit of area of a field.

The state of the exploration of a field can be adequately described by means of two maps: a reserves density map \( S(x) \), and a reserves density error map \( \sigma(x) \). They can be constructed on the basis of appropriate maps of geological parameters. From the probability theory point of view the field of oil and gas can be considered as a random field. Values of the reserves density map and the reserves density errors map at any fixed point can be treated as an expected value and corresponding variance of reserves density at the point. Moreover the random value of reserves density at a given point can be characterized by lognormal distribution. Initial maps used in the simulation procedure as input data are calculated by using real outcomes of the real test wells drilled before the computer simulation. An example of the initial state is shown on the initial reserves density map \( S_0(x) \) of Fig. 1 and on the reserves density variance map \( \sigma_0(x) \) in logarithmic scale of Fig. 2. Both maps were constructed by using geological information obtained earlier from the real test wells designated by circles on the map.

Fig.1. Initial reserves density map \( S_0(x) \).
Fig.2. Initial reserves density variance map \( \sigma_0(x) \) in logarithmic scale.

The first choice is made by the Decision Maker who selects the number of test wells that will be initiated at the first step and their allocations. In the example considered in this paper the first choice of the Decision Maker consists of a single test well which is designated by rectangle on the map. Then the first choice is made by the Nature which selects possible values of reserves density at each test well selected at the same step. The range of possible outcomes of the test wells and their probabilities can be calculated by using values of reserves density map and reserves density errors map at the corresponding points. Thus given point \( X \) of allocation of a test well the range of possible outcomes with the probability 0.997
will be \( (S_0(\chi)-3\sigma_0(\chi), S_0(\chi)+3\sigma_0(\chi)) \). Suppose that the number \( M \) of outcomes of a test well is given as an input parameter of the simulation procedure. Then the possible outcomes at the point \( X \) will be:

\[
\delta_i = S_0(\chi)-3\sigma_0(\chi)+3(2i-1)\sigma_0(\chi)/M, \quad i=1, 2, \ldots, M.
\]

After the choice of the Nature has been made, values of reserves density at each test well selected by the Decision Maker at this step are become known. The impact of a reply of the Nature on the state of the exploration can be evaluated by using a covariance matrix which is also the input data of the simulation procedure. Using initial maps and covariance matrix as well as the reply of the Nature we can calculate the new maps and covariance matrix that will describe our new knowledge of the field of oil and gas gained after the first step of the game. The procedure described here can be repeated at the second, third and so on steps to generate future exploration opportunities.

Denote by \( U \) a choice of the Decision Maker at the \( i \)th step of \( n \)-step game and

\[ u^i = (k^i, x^i_1, x^i_2, \ldots, x^i_{k^i}) \], \( x^i_j \in X^i \), \( j=1, 2, \ldots, k^i \), \( i=1, 2, \ldots, n \),

where \( k^i \) - the number of test wells that will be initiated at the \( i \)th step;

\( x^i_j \) - allocation of \( j \)th test well at the \( i \)th step, \( X^i \) - feasible set of test wells allocations, \( j=1, 2, \ldots, k^i, i=1, 2, \ldots, n \). Denote by \( v^i \) a choice of the Nature at the \( i \)th step and

\[ v^i = (y^i_1, y^i_2, \ldots, y^i_{k^i}) \],

where \( y^i_j \) - one of the possible outcomes at the point \( x^i_j \), \( j=1, 2, \ldots, k^i, i=1, 2, \ldots, n \).

Denote by \( V_i \) a set of all possible selections of the Nature at the \( i \)th step. Using known probability distribution of the outcomes, which according to our assumption is the multivariate lognormal distribution, we can calculate the probability \( p^i(v) \) of a selection of the Nature \( V \in V_i \) at the \( i \)th step. The probabilistic game between the Decision Maker and the Nature can be presented as a decision tree of Fig.3. It helps us to visualize all possible realizations of alternatives of the Decision Maker and the Nature. The decision tree of Fig.3

![Decision Tree](image-url)
includes only two steps of the game and only two alternatives for the players at each step. A rule of Decision Maker’s choosing at each step will be called a strategy. Any strategy of the Decision Maker can be illustrated as a sub-tree of the decision tree that includes only one alternative for the Decision Maker and the full set of possible alternatives for the Nature at each step. It can be expressed as the following vector function:

\[ f = (u^1, f_2(u^1, v^1), f_3(u^1, v^1, u^2, v^2), \ldots, f_n(u^1, v^1, u^2, v^2, \ldots, u^n, v^{n-1})) \]

where the function \( f_i(u^1, v^1, \ldots, u^{i-1}, v^{i-1}) \) uniquely determines the choice at the \( i \)th step.

Let \( \omega_n = (u^1, v^1, u^2, v^2, \ldots, u^n, v^n) \) be a fixed path that connects the initial node with one of the numerous final nodes. Since numbers and allocations of test wells at each step, as well as their outcomes, are known for the fixed path \( \omega_n \), we can evaluate: (1) the test well budget \( Z(\omega_n) \) which is required to realize selections \( u^1, u^2, \ldots, u^n \) of the Decision Maker; the final density map \( S_n(\omega_n) \) and the reserves density error map \( \sigma_n(\omega_n) \); (3) probability \( p(\omega_n) \) of realization of path \( \omega_n \). Using the maps \( S_n(\omega_n) \) and \( \sigma_n(\omega_n) \) we can evaluate a value of reserves \( Q(\omega_n) \), that will be explored with a given level of accuracy provided realization of the \( \omega_n \), and a corresponding exploration efficiency \( e(\omega_n) = Q(\omega_n) / Z(\omega_n) \).

Combining all paths \( \omega_n \) within a fixed strategy \( f \) of the Decision Maker and its possible outcomes we obtain the probability distribution of possible results of the exploration expressed in form of the distribution of values of reserves \( Q_f(\omega_n) \) and exploration efficiency \( e_f(\omega_n) \). Using this distribution we can evaluate financial risk \( r_f \) of the Decision Maker associated with the strategy \( f \). It can be expressed in two following forms:

\[ r_f = 1 / E e_f(\omega_n) \]

or

\[ r_f = P(e_f(\omega_n) \leq C) \]

where \( E \) denotes expectation, and \( C \) - minimal level of exploration efficiency that is acceptable for the Decision Maker. The goal of the Decision Maker is to choose such a strategy \( f \), that would minimize the financial risk \( r_f \) (maximize the effectiveness of capital allocations).

It should be noted that the approach presented here is in accordance with sequential statistical decision theory. It provides a mechanism for continually updating our knowledge about the field of oil and gas from step to step depending on Nature’s reply. This problem can be solved within the framework of sequential analysis.

3. CONCLUSIONS

The control of financial risk in management of exploration is the reduction of the probability of loss of money. The approach described in this paper provides a means of quantifying business risk by using maps of geological parameters to assign probabilities to possible outcomes of test wells drilling. Simulating multi-step process of test wells allocation provides possibility to investigate exploration in dynamics and construct the optimal strategy that minimizes risk.
TRACK 4

SESSION 3

DECISION MAKING
UNDER UNCERTAINTY
– METHODS
ABSTRACT
This paper presents the theoretical background for the use of expanded definitions of uncertainty and models of the science policy interface to examine the environmental decision making process. Current efforts in risk-based environmental decision making tend towards the application of decision theoretic methods to represent multiple value structures and priorities in the decision making process. This trend has been met with limited success, perhaps due to its maintenance of the separation of science and policy. We present models of the science-policy interface along with technical and social science definitions of uncertainty in order to develop the importance of an integrated approach to environmental decision making. Finally, we present a case that we are examining using these concepts.

INTRODUCTION
Recently, there have been several recommendations calling for new, integral approaches to risk-based decision making that incorporate economic, social, and cultural factors while maintaining a strong scientific basis [1, 2]. Unfortunately, there are limited resources available for the decision makers' incorporation of these disparate measures in the environmental decision making process and many researchers have turned, with limited success, to traditional decision theoretic methods.

As a contribution to the development of new decision making methods, we examine the science-policy interface of the environmental decision making process. Environmental decision making covers a broad spectrum of activities ranging from the design and implementation of governmental regulations to decisions that affect the restoration or protection of an individual site. In particular, we examine the selection and use of uncertain scientific and technical information, including models, measurements, and risk estimates in the decision making process and its role in the development of arguments and agendas.

In this paper, we merge technical and social science concepts of uncertainty and various models of the science-policy interface in order to gain insight into the environmental decision making process. We examine the design of California's motor vehicle inspection and maintenance (I/M) program, Smog Check. Our case study combines technical concepts of uncertainty with qualitative analysis of the processing of this information. Models of the science policy interface and expanded definitions of uncertainty are used to design and execute this study of the technical and policy components of the decision making process.

The following section presents an overview of expertise and uncertainty, models of the science-policy interface, and develops the relevance of these concepts to environmental decision making. The next section discusses the use of these concepts in the case study. The paper concludes with a brief discussion.
The science-policy interface and uncertainty

In this paper, we draw on two bodies of literature to provide tools for a multi-disciplinary examination of the decision making process. The first body of literature examines the science-policy interface. The second is the technical and social science literature discussing uncertainty. Both of these areas of literature provide useful analytical and conceptual tools for examining the environmental decision making process.

The Science-Policy Interface

Environmental decision making relies on inputs from the scientific and technical community in order to measure current environmental impacts, model future trends, provide estimates of human and ecological risk, and identify potential mitigation strategies. There are several models of the interaction between the science and policy communities. As Figure 1 shows, these models vary from a separatist two-way flow of information through to the regulatory science model. In this latter model science and policy mesh to form a new discipline called "regulatory science" where science and policy are fused to formulate and answer policy-relevant questions.

These models have important implications for the design of frameworks for environmental decision making. A separatist model supports traditional decision analytic approaches where science provides data and information and the decision makers process this information to reach an outcome. On the other hand, a framework that reflects the principles of regulatory science emphasizes the importance of the connection of the science and policy worlds. An example of such a framework is the analytic-deliberative process described by the National Research Council [2].

Studies of environmental decision making suggest that the latter interpretation of the science-policy interface is appropriate because there are often multiple interested parties reflecting a diversity of values and priorities [4-8]. The formation of knowledge and policy options become increasingly intertwined in these types of decisions. In response to the observation of the "co-production" of knowledge and policy options, there has been a trend in social science and science policy studies towards examination of the dynamics of problem framing and consensus building [9]. We use this constructivist approach in our examination of uncertainty in the environmental decision making process.
Uncertainty in Science, Policy, and Decision Making

Uncertainty is a useful vehicle for examining the interaction of science and policy in environmental decision making because of its importance in both components of the process. In order to get an idea of how broad the interpretations of uncertainty in the technical and social science communities are, we show six different uncertainty definition and classification schemes in Table 1. Each of these encompasses technical and social understandings of uncertainty. These definitions cover a broad range of sources and types of uncertainty. This breadth is important because it enables us to use the concept of uncertainty to examine the technical components of the decision making process (e.g., models, measurements, predictions) as well as to examine the process through which the information is used in the decision.

Table 1: Uncertainty Classification Schemes

<table>
<thead>
<tr>
<th>RESEARCHER</th>
<th>CLASSES OF UNCERTAINTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morgan and Henrion [10]</td>
<td>Uncertainty in empirical quantities</td>
</tr>
<tr>
<td></td>
<td>Uncertainty in model form</td>
</tr>
<tr>
<td></td>
<td>Structural uncertainty</td>
</tr>
<tr>
<td>Schrader-Frechette [12]</td>
<td>Framing uncertainty</td>
</tr>
<tr>
<td></td>
<td>Modeling uncertainty</td>
</tr>
<tr>
<td></td>
<td>Epistemic uncertainty</td>
</tr>
<tr>
<td>Funtowicz and Ravetz [13, 14]</td>
<td>Inexactness</td>
</tr>
<tr>
<td></td>
<td>Unreliability</td>
</tr>
<tr>
<td></td>
<td>Border with ignorance</td>
</tr>
<tr>
<td>Wynne [15]</td>
<td>Risk</td>
</tr>
<tr>
<td></td>
<td>Uncertainty</td>
</tr>
<tr>
<td></td>
<td>Indeterminacy</td>
</tr>
</tbody>
</table>

There is an important distinction between indeterminacy as defined by NRC and as defined by Wynne. NRC states that indeterminacy is uncertainty about which model to use. Wynne's definition of indeterminacy poses a question that overlays the entire science-policy interaction: Does policy direct science or is policy modified to justify science?

Several researchers have demonstrated the importance of uncertainty in the formation of arguments and agendas in the policy and decision making processes [13, 16-18]. In addition, uncertainty has been observed to facilitate communication between social worlds [19]. Uncertainty is equally important in the technical fields that contribute to environmental decision making [10, 20]. Due to its robustness, examination of decision making through uncertainty allows us to gain insight into the technical and policy components of the process.

Case Study Application

Our case study examines the design and implementation of California's motor vehicle inspection and maintenance (I/M) program. We are using the models of the science policy interface and the definitions of uncertainty presented above to examine the regulatory process. The case study consists of two components, one analytical and the other qualitative. The purpose of the analytical portion is to identify and, where appropriate, quantify uncertainties in the technical information that informs the environmental decision making process. The second portion of the case study is a qualitative interview and document analysis whose purpose is to trace the use scientific and technical information in the regulatory process.

This case study focuses on the stated objectives of the I/M program, the evaluation data that is available for the program, and how regulators use this information to design and update the I/M program. The I/M regulatory process is composed of overlapping science and policy...
communities that interact with the consumers and providers of the services required through the program, as shown in Table 2.

Table 2: Communities involved in the I/M regulatory process

<table>
<thead>
<tr>
<th>POLICY COMMUNITY</th>
<th>SCIENTIFIC COMMUNITY</th>
<th>CONSUMERS AND SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Environmental Protection Agency</td>
<td>California Air Resources Board</td>
<td>Drivers</td>
</tr>
<tr>
<td>Bureau of Automotive Repair</td>
<td>“Independent” Scientists (contracted studies)</td>
<td>Mechanics and station owners</td>
</tr>
<tr>
<td>California Air Resources Board</td>
<td>State I/M Review Committee</td>
<td></td>
</tr>
<tr>
<td>State I/M Review Committee</td>
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</tbody>
</table>

Examination of the interactions of these groups through interviews and document analysis demonstrates how their use of science in the regulatory process reflects agendas and values. The merging of quantitative and qualitative analysis of the regulatory process is necessary to gain an understanding of the co-production of knowledge and policy options. This research, in turn, provides the foundation for an environmental decision making framework that recognizes and takes advantage of this co-production.

DISCUSSION

This paper presents models of the science-policy interface and definitions of uncertainty as tools for exploring the environmental decision making process. Preliminary work shows that uncertainty is a useful analytical tool for examining the technical and socio-political components of environmental decision making in order to gain insight into the formation of arguments and agendas. These two concepts show great promise as the basis for the formation of an integrated environmental decision making framework.

ACKNOWLEDGEMENTS

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A COMPARISON OF CBA AND MAUT FOR ALARP DECISION-MAKING

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ABSTRACT
We assess the suitability of cost-benefit analysis (CBA) and multi-attribute utility theory (MAUT) for performing ALARP ('as low as reasonably possible') assessments, in particular within the nuclear industry. Three problems stand out in current CBA applications to ALARP, concerning the determination of prices of safety gains or detriments, the valuation of group and individual risk, and calculations using 'disproportionality'. Multi-attribute utility methods provide an alternative methodology, which through sensitivity analysis can address the perceptions of all stakeholder groups, facilitating constructive discussion and elucidating the key points of disagreement. We also argue that by being explicitly subjective it provides a open, auditable and clear analysis in contrast to the illusory objectivity of CBA.

INTRODUCTION
ALARP and ALARA ('as low as reasonably achievable') are essentially equivalent principles within the UK safety assessment principles (SAPS) (HSE 1992, Pape 1997) and supported by the ICRP (1977). The basic safety objective (BSO) and basic safety limit (BSL) give 'ideal' and upper limits to the probability of death as a result of activity or operation of plant; the ALARP region lies between. Here the trade-off between safety and the cost of implementing improvements is made on the basis of what is 'reasonably practicable'. Although the ALARP principle, superficially, concerns lowering risk towards the BSO, it may be applied to accept an increase risk. Also, the principle may not give clear guidance when decisions require not just a cost/risk trade-off, but also a trade-off between different types of risk. Our aim is compare the current implementation of ALARP in the UK with decision analytic methods, in particular, MAUT. In many respects, we adopt a regulator's viewpoint. We would like to acknowledge the support of MC contract Task PRA/GNSR/5032 for part of the research reported here; but we emphasise that the views expressed here are our responsibility.

ECONOMIC AND CBA BACKGROUND
CBA is a technique from economics, and is particularly popular in Treasury or Finance Departments (see, e.g., HM Treasury, 1996). CBA attempts to identify and express in monetary terms all aspects of the potential consequences of a decision. The value of a decision equals net expected benefits minus net expected costs. The 'objectivity' of a CBA study depends on the extent to which, firstly, all relevant consequences and, secondly, 'objective' prices and probabilities can be unambiguously determined. It is rare, however, for the same legal entity to both receive the benefits and pay the costs. Hence, CBA proponents take recourse to the Kaldor-Hicks Principle (Layard, 1972), arguing that those gaining could in principle compensate those losing. In practice, compensation rarely happens, although some possible mechanisms do exist; e.g. utilities could reduce prices to compensate the public at risk.

Willingness to Pay, Willingness to Accept and Equity
The underlying philosophy of CBA focuses on market prices; but even for objects that are traded the choice of market may well influence the price (e.g. geographical variation in house prices). For many CBA applications there is no clear market to determine the values (e.g.
human lives); so often, one applies the contingent valuation method (CVM), essentially survey techniques using willingness to pay or willingness to accept questions (Adams, 1995). The distinction between willingness to pay (WTP) and willingness to accept (WTA) is important, even though it is frequently ignored or blurred: e.g. HM Treasury (1996) does not mention WTA. The amount of money an individual can pay is limited by their wealth, and could differ greatly to the amount of compensation they might accept. Whether one should use WTA and WTP depends critically on how the problem is framed (Adams, 1995). Consider the difference between BSLs and BSOs:

- If the aim is to get as near to the BSO as possible, then a utility should be willing to pay for a (commercial) benefit which will increase risk away from the BSO. The public, on the other hand, will be willing to accept compensation for taking the extra risk.
- If the aim is to simply keep under the BSL, then the public should be willing to pay for the benefit of a further risk reduction towards the BSO. The utility, on the other hand, will be willing to accept compensation for forgoing the right to use the extra risk margin.

The ALARP principle seems to be applied more usually the first of these contexts. Thus one may argue that WTA valuations should be used, contrary to common practice and the advice of the regulator (HM Treasury, 1996).

Uncertainty and disproportionality

In some CBA studies, 'disproportionality factors' are used to multiply cash outcomes. These weights seek to take account of social or political preferences such as 'safety first'. Within CBA there is no theoretical justification for this, although some view it as 'taking account' of the uncertainty in calculations (Pape, 1997). In practice, in ALARP studies uncertainty is first removed by taking averages, and then a check made on disproportionality. In fact, decision theoretical considerations suggest that the averaging should be done after weighting. One faces a further problem in the way that expectations are taken. The 'Tolerability of Risk' criteria are phrased in terms of individual risk rather than group risk. Indeed, there has been disagreement about the necessity to consider group risk at all. Given that the ALARP region is defined as being between the BSL and BSO of individual risk, it would seem logical to navigate within this region using a metric based on individual and economic risks. However, the current ways of taking expectations within CBA for ALARP decision making seem to determine the costs in terms of the group effects. This seems to be highly inconsistent.

These remarks barely skim a general critique of CBA; many objections are well known and for these reasons Vaughan (1996) stresses the importance of qualitative factors such as good engineering principles and practices.

DECISION ANALYSIS

Decision analysis is based upon a model of a rational decision maker (DM). Subject to consistency conditions the model can express the beliefs and value judgements of any individual in society. Usually, differences between individuals in society are reflected in the weights that they place upon different factors or in the likelihood of some event. By a careful use of sensitivity techniques, an analysis can identify which differences are key and thus focus debate on the issues that matter. It can often be shown that despite differences in judgements many elements of society agree on the course of action, thus diffusing sterile debate. Decision analysis separates beliefs and value preferences, models and analyses each, and then recombines them to guide the ranking of alternatives. This separates Science, quantified by scientists and engineers, from value judgements about the worth of the consequences, which can be expressed and explored by many stakeholders — a far wider group than scientists and engineers: see French and Smith (1997, Chapter 1).
Value-focused thinking and the structuring of objectives

The first step in a decision analysis is one in which the DM and analyst structure the representation of the consequences. An attribute tree is developed, which summarises and organises the key values to be taken into account (Keeney, 1992). Figure 4 suggests a possible structure for an attribute tree which might be used in an ALARP decision. ALARP issues are gathered together into one sub-hierarchy, focusing attention on safety matters covered by regulation: company issues are collected elsewhere; and so on. Thus the attention of the regulator, company and other stakeholders may be focused on these prime issues at key stages in the analysis. Similarly, the attributes which reflect the values of other stakeholder groups are gathered together in another sub-hierarchy. During the sensitivity analysis, weights applied to different parts of the tree will be varied to explore the differences in values and perceptions by the different parties to the decisions.

Once an attribute tree has been defined, the consequences are represented as a vector of scores against the different attributes, \( c = (c_1, c_2, \ldots, c_q) \). Note that there are auditable ways of eliciting meaningful subjective scores (Keeney, 1992). The next question concerns the form of a multi-attribute utility (MAU) function, \( u(c_1, c_2, \ldots, c_q) \). A simple MAU function, which can reflect the different risk attitudes that partly motivate disproportionality, utilises a linear value function combined with an exponential transform:

\[
U(c_1, c_2, \ldots, c_q) = 1 - e^{-\sum_{i=1}^{q} w_i c_i / \rho}
\]

The parameter \( \rho \) directly encodes risk aversion. This is only one example of many possible forms for the utility function (Keeney, 1992).

Sensitivity Analysis

Sensitivity analysis moves us from guidance and analysis for a single individual, to providing support and enhancing understanding across groups, different stakeholders and society. Sensitivity analysis plays two major roles in the context of ALARP decision making. From the technical perspective the analyst and decision maker can check whether there is a clearly preferred alternative, or whether there are several strongly competing alternatives. The social perspective helps groups of decision makers focus on real differences, e.g., a sensitivity analysis can show that, despite differences on the weights, the decision should be the same.

Critique of multi-attribute utility methods.

The main problems perceived in the use of multi-attribute utility methods are: difficulty of trading off very different kinds of attributes; subjectivity of the problem structure and weightings used; and consistency from one decision to another. No elicitation method can make the task of trading-off easy, but it can give the DMs insight into the way in which the optimality of the solutions depends on the trade-offs. Subjectivity is present in CBA analyses,
e.g. through the choice of market; the MAUT approach simply makes the inherent subjectivity in decision making explicit. Sensitivity analysis can be used to investigate the importance of subjective choices. Consistency from one situation to another is important in safety decisions, particularly those subject to regulation. The current CBA/ALARP methodology offers a certain level of consistency, but it is an inappropriate consistency. MAUT analyses can quantify core attributes on the same measurement scales in all decisions and include more-or-less standardised weights as initial values in the sensitivity analysis for those attributes which consistently arise. Databanks can be built up to provide a ‘memory’ of past trade-off choices against which decisions can be audited.

CONCLUSIONS
Pape (1997) list seven key points that ALARP decision making should address. On five points, the difference between MAUT and CBA is minor. On two points there are, however differences: “The whole range of health and safety detriments relevant to the system in question should be considered.” The multi-attribute structure which underpins MAUT provides precisely the mechanism in which this may occur. Because the methodology allows both objective – in the sense of consensually agreed – and explicitly subjective factors to be considered, all health and safety detriments may be included in the analysis.

“A risk reduction measure should be implemented where the cost is proportionate to the safety gain, at whatever financial inconvenience to the company. (This ensures a level playing field between companies, with consistent safety standards across the board.)” CBA analysis does have a superficial advantage here in that consistent costs are used throughout. However, we have argued that the consistency is illusory, and, since CBA does not allow the modelling of intangibles, the influence of these may be highly inconsistent. The use of MAUT with a database of past decisions would aid the process of ensuring consistency of decisions.

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SENSITIVITY ANALYSIS OF RANKED INDUSTRIAL WASTE STREAMS IN PORTUGAL

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ABSTRACT
Environmental risk management strategies can benefit from the use of risk-based prioritization of efforts. One tool available for ranking environmental hazards is comparative risk assessment, which offers the benefits of limited data requirements, at a relatively inexpensive cost. A limitation of this approach is that the results are often expressed in qualitative terms which do not express the uncertainty associated with the assessment. This paper proposes a quantitative approach to incorporate the uncertainty of the inputs to the comparative risk assessment. Input model parameters were expressed as probability distributions. Random sampling from these distributions in Monte Carlo simulations allow the resulting hazard ranking to be expressed as probability distribution rather than single value.

The process is applied to a case study of industrial waste streams in Portugal, where environmental waste management decisions are being made based on a limited analytical data regarding their impact on the environment. A total of eleven hazard ranking scales were developed to compare risks across industries, cities, and industrial zones to help prioritize industrial waste management policy development. The scales represent various aspects of toxicity and exposure, such as environmental persistence, or exposure from food sources. Generally, industries that produce inorganic wastes pose more risk to public health and the environment than industries that improperly dispose of spent solvents. When considering geographic differences in exposure, regions with relatively significant dietary exposures to wastes ranked higher than regions where water use for drinking or irrigation was a more significant exposure pathway. The uncertainty analysis improves the overall utility of ranking of hazards for use in environmental decision making by providing more complete information about the range of possible outcomes.

INTRODUCTION
Risk based prioritization can be a useful management tool for a variety of environmental hazards because it decision alternatives may be compared on criteria relevant to the decision. In a methodology previously developed to rank industrial waste (Shatkin et al. submitted for publication), a qualitative risk ranking based on five characteristics important to overall risk: human toxicity, ecological toxicity, bioaccumulation potential, environmental persistence, and waste quantity.

Alternatives to address environmental hazards can be compared for public health, environmental, and other societal impacts, providing managers with transparent decision criteria and a semi-quantitative risk-based foundation for decision making. The methodology developed requires limited analytical effort and is an inexpensive alternative to large detailed studies for setting priorities based on risk in the early stages of environmental planning.
In this current effort, we incorporate uncertainty into the semi-quantitative method recently developed to rank hazards. In this paper, we present the methodology, discuss its use and applicability, and apply the method to rank industrial wastes in Portugal.

CASE STUDY

12 Portuguese industries were reported as producing hazardous industrial waste, and are studied in a report done by Tecinvest (Tecinvest, 1997). All industries that produce hazardous waste streams are obliged to report annually the type of waste generated by EU hazardous waste code and quantity. We limit this study to these 12 industries, because we do not have data for additional industries, although they may contribute to environmental risk in Portugal, their wastes are not considered hazardous by the EU.

For each industry, hazardous waste type and quantity were reported. European and US reports on industrial processes and pollution prevention were consulted to determine likely chemical components for each of the reported waste streams. The US EPA Waste Management Prioritization Tool (USEPA, 1997), Beta Version 1.1 (WMPT) was used to rank chemical components on four scales that represent different aspects of environmental toxicity of chemicals. We adopted these scales and created a matrix for each industry.

For each industry, all liquid and solid wastes reported were listed by European Union hazardous waste code. For each EU waste code, the values for four of the five criteria (human toxicity, ecological toxicity, environmental persistence, and bioaccumulation potential) represent the distribution of assumed chemical components derived directly from the draft Prioritized Chemicals List (PCL), using scores from the WMPT (US EPA, 1997). This source was chosen because the toxicity information had already been reviewed and rated on a semi-quantitative (low = 1, medium = 2, high = 3) scale for most of the identified waste constituents, and was based on current toxicity data. An alternative source of data, not ranked using scales, is HEDSET, the EU Harmonised Electronic Dataset. However, many of the chemicals in our study were not listed in HEDSET. Waste quantity is the base 10 logarithm of the reported quantity, with a 10% assumed error in reporting.

PROBABILISTIC RANKING

For each industry waste code, chemicals likely to be present were listed and ranked on the scales. The distribution of all chemicals was used as the input to define the waste code. Because the scales were in the range of 1 to 3, triangular distributions were selected to represent waste code scores.

Triangular distributions were defined for each waste code as follows. For waste codes with only one defined chemical, a triangular distribution with the most likely value equal to the WMPT code, and a standard deviation of 10% of the chemical WMPT code. For waste codes with several likely chemical components, the rank value is assigned as the triangular distribution, with the most likely, minimum, and maximum values calculated by Crystal Ball® Version 4 according to the following formulas:

If \( \text{Min} < x < \text{Likeliest} \), then

\[
F(x) = \frac{h(x - \text{Min})}{\text{Likeliest} - \text{Min}}
\]
If Likeliest \(<x<Max, then
\[
F(x) = \frac{h \cdot (x - \text{Likeliest})}{\text{Likeliest} - \text{Max}} + h
\]

Where:
\[
h = \frac{2}{\text{Max} - \text{Min}}
\]

If all input chemicals had the sample value, the standard deviation was assumed to be 10% of the value. A triangular distribution was used because the rank values are already representing ranges of input data.

Each industry type is ranked on each of the five scales with the 95th Percentile value of its waste code scores. The overall ranking for each industry is the sum of 95% across the five scores.

**PRELIMINARY RESULTS**

Figure 1 presents the cumulative distribution for toxicity ranking for 12 Portuguese industries. The range of ranking values varies across industries, reflecting the uncertainty of the input variables. The industries with more uncertain or diverse data cover a broader range, e.g., overall rank of Commerce and Services industry ranges from 12.3 to 16.6, versus the Inorganic Chemical industry which ranges from 14.9 to 15.9 in the ranking. The rank of some industries are less certain, e.g. the distribution for Pharmaceuticals is very close to those of Diverse Chemical Industry. Generally, however, there is little overlap among the ranking of different industries when presented as a cumulative distributions. The results show that overall, the Inorganic Chemical industry ranks highest among environmental and health threats from industrial waste in Portugal. In addition, it is clear that there is less uncertainty regarding the toxicity of this waste stream than in other industries, such as Commerce and Services. If desired, more data can be obtained to reduce uncertainty.

**CONCLUSION**

The ranking allows decision makers to select priorities based on risks to human health, environmental toxicity, waste quantity, and transport and fate characteristics with awareness of the uncertainty in the risk assessment process. By incorporating a range of possible inputs, the ranking becomes more robust, and the uncertainty in the resulting risk ranking can be presented explicitly. Current work is focused on site specific unceert
FIGURE 1. Toxicity Ranking for Waste Streams of 12 Portuguese Industries

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ABSTRACT
We are facing an increase in the complexity of societal issues. Risk analysis is one of the approaches that can be used to address complex issues for the sake of decision-support. However, fundamental controversy within the risk analysis community implies that there is neither agreement over appropriate methods for risk assessments nor acceptance of the outcomes of public processes. In this paper, it will be argued that one of the reasons that the above risk debate is still alive, is that the inevitability of incomplete knowledge and the omnipresence of uncertainty are not fully recognised, acknowledged and accepted. The key challenge for risk analysis in the light of this conclusion is to accommodate uncertainty both in thinking about risk and in assessing risk. Furthermore, uncertainty and risk are interrelated on the following levels:

- the uncertain reality of what may occur
- the uncertain analysis of assessing the uncertain risks
- the variable evaluations of the uncertain risk analysis

An integrated approach to uncertainty and risk seems especially needed in the case of strategic risk issues, i.e. risks that cannot be controlled by individuals, nor exactly located, the time horizon usually transcends the short-term and the level of uncertainty associated with this type of risks is high. The paper discusses an integrated approach to uncertainty and risk, i.e. the Pluralistic Framework for Integrated uncertainty Management and risk Analysis (PRIMA), that is currently under development. Central to this approach is the recognition that multiple interpretations of uncertainty and plural perceptions of risk are legitimate. It is meant as a heuristic framework that can be applied in quantitative (esp. modelling) and qualitative assessment efforts.

In summarising the PRIMA-approach, this paper focuses on the phase “risks in perspective”, where we discuss how current approaches to risk and insights into risk analysis can be used in an integrated approach. The paper furthermore discusses the main experiences with applying the PRIMA-approach in the context of assessing environmental risks. The latter is done in the context of the environmental assessment efforts of RIVM, the Dutch Environmental Planning Agency. RIVM is currently preparing the 5th National Environmental Outlook, and the PRIMA-approach is used in this assessment process. The paper will summarise the experiences so far.
FRAGMENTATION, CONVERGENCE AND HARMONISATION: WHERE ARE WE GOING WITH INTEGRATED DECISION-MAKING?

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ABSTRACT
The desire to integrate technical, socio-political and economic factors within environmental decision-making has resulted in the development of several “frameworks” that promote a holistic approach. We explore the interfaces of the decision tools that comprise these frameworks and examine some of the common problems with integrated decision-making. Recent developments in the practice of risk assessment are used to illustrate issues of fragmentation and integration.

INTRODUCTION
Environmental decision-makers have at their disposal a vast array of support tools that have been developed over the last 30 years (Table 1). In the main, these tools have been applied with specific uses in mind and there has been little meaningful cross-fertilisation between them. Typically, as practice of a tool develops, users modify a ‘core’ protocol for their specific ends, with varying degrees of fragmentation then resulting throughout the practitioner community (Figure 1). With global and regional trade agreements and environmental regulations acting as stimuli, an emphasis on the harmonisation, convergence and integration of tools has understandably emerged. Further, the integration of social, economic and technical impacts in response to the sustainable development agenda is resulting in shifts within the structure of individual tools and acting as an additional driver.

Figure 1: Life-cycle for decision-making tools: from conceptualisation to harmonisation

Fragmentation, harmonisation and convergence
The widespread application of decision tools to the needs of specific environmental problems often leads to modification of a ‘core’ approach. Tools are increasingly applied at the policy, strategy and site-specific level of analysis (vertical modification) and across a full spectrum of environmental issues (horizontal modification). The nesting of ‘tools within tools’ (concentric modification) can result in further changes. For example, risk assessment has been applied for assessing the impacts of regulatory policy (financial focus), for process plant...
incident analysis (HAZOP/HAZAN focus) and within environmental impact assessments (usually, a health effect)

Table 1: Synopsis of Support Tools for Environmental Decision-Makers

<table>
<thead>
<tr>
<th>Tool</th>
<th>Use</th>
<th>Arena in which applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life cycle analysis</td>
<td>Energy and mass balance from cradle to grave of products (and policies)</td>
<td>Manufacture; product replacement and substitution; clean production and waste minimisation; supply and product chain management; ‘green’ accounting</td>
</tr>
<tr>
<td>Environmental risk assessment</td>
<td>Estimation of probability and consequence, usually for adverse environmental impacts at the site specific level, but can be applied at policy level as strategic risk assessment (SRA)</td>
<td>Chemical product licensing, manufacture and use; production plant safety; environmental health protection; flood defence; liability auditing; contaminated land assessment; policy analysis; strategy setting</td>
</tr>
<tr>
<td>Environmental (impact) assessment</td>
<td>Environmental, social and economic impacts of planned developments and summary in non-technical language; participatory approach advocated; can be applied at the policy or sectoral level as strategic environmental assessment (SEA)</td>
<td>Environmental planning; siting of contentious installations (e.g., incinerators, landfills, tidal barrage); policy analysis; business sector analysis</td>
</tr>
<tr>
<td>Cost-benefit analysis</td>
<td>Evaluation of social costs and benefits in investment projects and policies</td>
<td>Flood defence appraisal; BATNEEC and BPEO assessments; policy appraisal and regulatory impact assessments</td>
</tr>
<tr>
<td>Multi-criteria analysis (MCA) and multi-attribute techniques (MAT) Environmental audit</td>
<td>Integration of technical, social and economic factors (monetisable/quantifiable and non-monetisable/quantifiable)</td>
<td>Assessment of risk management options</td>
</tr>
<tr>
<td>Sustainability appraisal</td>
<td>Account of activities and production and resulting effects on environment; usually undertaken by an independent team with management support; the collation, analysis, interpretation and documentation of practices relevant to environmental requirements; checklist and Y/N guide approaches are common</td>
<td>Improvement plans; setting insurance premiums; corporate environmental accounting and statements; liability (acquisitions and divestitures); regulatory compliance; efficiency of environmental management systems (EMS); due diligence; waste minimisation</td>
</tr>
</tbody>
</table>

focus) and environmental audits (liability focus). Even in the relatively new and evolving field of strategic assessment, as applied to policies, programmes and plans, there remains the risk of fragmentation. Strategic environmental assessment (SEA), strategic risk assessment,
sustainability appraisal and multi-criteria analysis are all being developed in parallel and in some cases in isolation. Potentially, this is both inefficient and ineffective.

Stimuli such as globalisation, the internationalisation of regulation, the sustainable development agenda and corporate environmental reporting suggest that these tools increasingly need to interface more meaningfully with one another. The advantages include utilisation of outputs by others; easier communication between decision-makers and a genuine progression towards integrated decision-making.

Integration - What do we mean by integrated decision-making?

Integration within projects. ‘Integration’ can be mistakenly painted as a panacea, however. In the decision-making context, there is a multitude of definitions. Some appraisal techniques, for example, have been criticised as being ‘justificationist’, meaning that they tend to have been used to support a decision that has already, or is about to be, made. Environmental impact assessment, for example, has often been considered as a final stage regulatory obstacle to be ‘overcome’ in pursuit of planning permission. This attitude, if embodied in practice, restricts the ability of EIA to modify the environmental consequences of a project. It can then be argued that the proponent fails to gain the full benefits of the assessment process. Rather, environmental assessment needs to play a role at all stages in the decision-making process from inception through to construction, operation and decommissioning. Given appropriate resources and timescale this form of integration should be achievable.

Historically, there has been a lack of political and legislative support for integrated approaches to decision-making. In the UK, however, there are a growing number of examples. The Government’s Strategy for Sustainable Development makes clear the desire to consider social progress alongside effective environmental protection, the prudent use of natural resources and the maintenance of high and stable levels of economic growth. Specifically, the Government has strengthened mechanisms for integrated appraisal. For example, options for solving transport problems are compared and decisions taken in the light of environmental, social and economic impacts.

Integration between tools. The literature has a growing number of references on the links between cost-benefit analysis, EIA, life-cycle assessment and risk assessment. Integration of tools and techniques themselves is complex. There are very few role models to follow and inter-disciplinary approaches often suffer from a protectionist stance within disciplines and a lack of an epistemological framework within which integration can be theorised. Furthermore, existing tools have often been applied inconsistently and not in a transparent manner, leading to suspicion and low levels of credibility. A number of general challenges emerge when tools and techniques are combined to provide integrated support tools for environmental decision-making (Table 2).

Integration within tools and ‘the greening of risk assessment’. The contributions to the risk debate from the social sciences are having considerable influence on the practice of environmental decision-making. There are recent examples of elements from cultural, prospect and game theory being applied. The advantages of integration include involving stakeholders, incorporating wider costs and benefits, and adapting processes to uncertainty. Our experience indicates that it is possible to adapt techniques to allow for integration.
Risk assessment is now increasingly being viewed in participatory terms, in response to the 'risk society' debate, the risk communication literature and the environmental justice agenda, together with a growing understanding of scientific values. Calls for increased stakeholder involvement from 'problem definition' through to the framing of risk estimates, and the transition to a 'right-to-know' society are requiring greater access to these assessments. Mechanisms for stakeholder involvement, however, are not well-defined and to date, procedures have not been clearly evaluated. We need to establish at what stages, and in what ways involvement can be meaningfully incorporated. The current debate on deliberative and inclusionary processes will inform this development. However, a sustained attack on science and a lack of regard for the complexities of inclusionary processes could itself risk placing the desire for consensus above a rigorous scientific evaluation of risk. The challenge is to develop informed processes that enable decisions involving science to be widely debated in a social context.

### Table 2: Integration: some key challenges

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying the full aspects of a problem</td>
<td>Time needs to be invested at the outset to determine these. For example there may be a mix of traditional EIA issues, risk and potential social impacts.</td>
</tr>
<tr>
<td>Setting boundaries for analysis</td>
<td>These need to be established at the outset both for consistency and for transparency. For example, there is a growing interest in EIA approaches encapsulating the entire life cycle of a project, ranging from the winning of raw materials to the final decommissioning and disposal stages. There is a danger of becoming overwhelmed in detail.</td>
</tr>
<tr>
<td>Selecting individual techniques to potentially solve a problem</td>
<td>It is difficult to find off-the-peg techniques that are scientifically respectable, professionally and socially acceptable. There is a dearth of guidance. At present a wide range of methods exist from formal frameworks such as Risk Assessment, EIA and CBA to deliberative approaches. Any single problem may require a unique or novel approach.</td>
</tr>
<tr>
<td>Linking techniques together as appropriate</td>
<td>This is difficult because of the specific boundaries that surround techniques. Often it will be necessary to combine qualitative and quantitative information. Further, models on which techniques are based may be incompatible.</td>
</tr>
<tr>
<td>Consideration of increased public involvement</td>
<td>Current calls for increased public participation. There is considerable experience in EIA but not in CBA or technology assessment. Structured and focussed approaches are necessary, together with an examination of institutional structures and their capacity for meaningful public involvement.</td>
</tr>
</tbody>
</table>
Table 2: Integration: some key challenges (continued)

<table>
<thead>
<tr>
<th>Consider values</th>
<th>Deliberation is away of uncovering social values, but there are challenges as to how those values are incorporated meaningfully into decision-making.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handling uncertainty</td>
<td>Recognition that in addition to uncertainty, there may be areas of ignorance where the precautionary principle may be appropriate. Sensitivity analyses can show the results of appraisals as ranges rather than discrete numbers.</td>
</tr>
<tr>
<td>Using experts</td>
<td>The appraisal community is now taking on board participatory methods, combining scientists and non-experts. This is not unproblematic and methods of sharing technical information need to be developed and interrogated.</td>
</tr>
<tr>
<td>Deciding which timescale is appropriate</td>
<td>For example, sustainable development requires a longer-term perspective to be taken. There may be a need to undertake scenario building in parallel with a particular appraisal technique.</td>
</tr>
<tr>
<td>Trading-off one option against another</td>
<td>There are particular challenges surrounding the choice of decision factors, the use of ranking, rating or scaling and, more controversially, weighting.</td>
</tr>
<tr>
<td>Post-project analysis</td>
<td>It is imperative that the process is evaluated and lessons learned.</td>
</tr>
</tbody>
</table>

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TRACK 4

SESSION 4

ROLE OF EXPERTS
TRACK 4
SESSION 4
ROLE OF EXPERTS
Bounding Risk, Bounding Science –
STANDARD SETTING FOR OCCUPATIONAL CHEMICALS

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ABSTRACT
Governments in all industrialized countries have developed policies to regulate the risks of new and existing technologies. Central to these regulations are exposure standards, which function as the cornerstone for further policy making and preventive measures. Standard setting bodies have been set up, that are mandated to provide for standards that are both able to protect health and the environment, and that can be implemented in industries. But how do such organizations work in practice, and how is the boundary between science, interests and policy drawn and maintained by those organizations? On the basis of both in-depth case studies and international comparisons of standard setting for occupational chemicals, this paper will argue that there is no \textit{a priori} distinction to be made between science and non-science, but that this distinction is the result of concrete interactions within the process of standard setting, so-called ‘boundary work’. Furthermore, in order to be productive, standard setters have to translate the contingencies they find in practice into the rationalities that are asked from them by the provider of the mandate. In order to do this, specific tools have evolved in standard setting practices, that enable the co-ordination of the formal and the informal. This analysis of standard setting serves as a caution to all to optimistic uses of ‘transparency’ as the way to go forward in risk assessment and management.

INTRODUCTION
Transparency has become the buzzword in talking about risk management and assessment. Whenever procedures for the assessment or management of risk are transparent, it is now widely believed, they will also be more democratic and effective. That is to say, such procedures, by providing information and a possibility to participate in all steps taken, are seen to have a greater legitimation, and will at the same time be more effective in tackling risk issues. The cultural background to the idea of transparency is most surely American, as it resonates highly with the American idea of openness of all government actions and a stress on participatory – as an antidote to representative – styles of policymaking (see e.g. Jasanoff 1998). Because of widely diverging policy styles in Great Britain and on the Continent (e.g. Renn 1995), it is a legitimate question if such a stress on transparency will work in a European context.

PRODUCTIVITY AND THE BOUNDING OF DOMAINS OF DISCRETION
In this paper, I will start to address that question with an analysis of standard setting for occupational chemicals in the Netherlands, so-called Maximum Allowed Concentrations, or MAC-values. Elsewhere, I have shown Dutch standard setting for occupational chemicals to be relatively productive as compared to UK and US standard setting procedures (Bal 1999). Productive standard setting is defined as a combination of three requirements. First, such processes must indeed lead to the setting of standards. Second, these standards must be compatible with the hygienist goals that drive standard setting; that is, they need to protect
workers as much as possible. Third, the standards need to be implementable in practice; that is, they need to be accepted by workers and industry, and they need to be technologically and economically feasible. Productive standard setting processes lead to many standards, which in principle protect workers health, and are implementable in practice.

Meeting these three requirements makes productive standard setting a complex process, in at least two different ways. First, the requirements themselves can be, and sometimes are contradictory. Second, standard setting requires the involvement of at least three different groups of actors — governmental organizations, interest groups and scientific experts — who bring different goals and views to the matter, and cannot be bureaucratically controlled.

Within standard setting procedures, two different techniques are used to cope with this complexity. First, rules are set that regulate the kinds of actors that are to participate in the setting of standards, as well as their respective tasks and their mutual relations. This set of rules is the mandate of standard setting procedures. Second, an organizational design is made, that is directed at a differentiation and integration of the tasks that are defined within the mandate. In productive standard setting procedures, the mandate and the organizational design are directed at a differentiation and integration of the respective views and goals of actors — at a reduction of the ‘heterogeneity overload’ within the procedure by distinguishing different domains of discretion.

In studying standard setting procedures, one has to make a distinction between two kinds of rules. First, rules external to practices, directed at their regulation, that have a function in bounding these practices from other practices. These rules also function as the external legitimization of practice. Second, immanent to the practices, rules function to get the work done. That is, they enable actors to deal with different circumstances that cannot be handled through external rules, and to repair inconsistencies. Actors within practices can refer to both kinds of rules in their activities. That is, they can both use a rationalistic repertoire, referring to the external rules, and a contingent repertoire, referring to immanent rules and circumstances (Gilbert & Mulkay 1985). The productivity of such practices then appears to depend on the ability of actors to translate immanent rules into external rules, or the contingent repertoire into the rationalistic.

Within standard setting processes, this process of translation is directed towards distinctions between domains of discretion. Such distinctions cannot be made a priori. That is, distinctions between domains do not refer to essential characteristics, but are (social) constructions. Distinguishing science from non-science, for example, is a matter of boundary work, or, the attribution of specific issues to domains of discretion. Productive standard setting then depends on the reproduction in practice of domains of discretion as defined in the standard setting mandate.

The literature identifies co-ordination tools that enable this process of translation. An example are boundary objects — social, discursive, or material instruments, that are both robust enough to be used in different contexts (and thus enable communication across boundaries), yet plastic enough to mould them to the needs of particular practices (Star & Griesemer 1989).

DUTCH STANDARD SETTING FOR OCCUPATIONAL CHEMICALS

The history of the MAC-procedure has been intimately tied up, both with the development of Dutch social medicine and toxicology, and with the relations between government, unions, industry and scientists in the Dutch welfare state. The Labor Inspectorate, in combination with the upcoming field of industrial medicine, has been particularly active in building up expertise. Early standard setters, most prominently Zielhuis, discussed ways in which the regulation of occupational chemicals should proceed. Two elements were to be central: an
'interdisciplinary discussion', in which disciplines would refer to experts, government, workers and industry, and the establishment of a 'threshold dose' or concentration.

The MAC-procedure, which was installed in 1976\textsuperscript{20}, was very much based upon these two principles. Three domains of discretion were distinguished – a scientific domain, a domain of interests and a policy domain – which were hierarchically integrated within a three-step procedure. In this procedure, the Dutch Expert Group on Occupational Chemicals (DECOS) takes the first step, by evaluating the available literature on a given substance and proposing a ‘health-based exposure limit’. This limit forms the input for the ‘MAC-committee’, made up of industry, unions and government representatives, which discusses the feasibility of the health-based standard and proposes a ‘feasibility standard’. In the last step of the procedure, this feasibility standard is evaluated for policy implications and the final standard is established by the Ministry of Social Affairs and Employment as binding for all workplaces.

The development of the organizational design of the MAC-procedure from the late 1970s onwards, shows an increasing organizational distance between the three domains. While at the start the whole procedure was more or less internal to the Ministry of Social Affairs, first the MAC-committee and later DECOS were externalized and made part of larger advisory bodies (the Social Economic Council and the Health Council, respectively).

As more stress is put on the separation of domains, the productivity of the MAC-procedure increasingly depends on the integration of these domains and the relation between the procedure and the practice of standard setting.

In 1976, DECOS was given the task “to prepare the scientific evaluation of dangerous substances and provide advise in these matters, in order to gain insight into the toxicological aspects of these substances.” This general formulation was later supplemented by more specific mies as to the ways the committee should proceed in its task. However, the committee was attributed much discretion as to the ways it would collect its information, select the ‘critical effect’ for a substance as well as the ‘no-effect-level’, and decide upon a safety or uncertainty factor. Furthermore, it was given almost complete control over the selection of members of the committee. Precisely these aspects of DECOS’ discretion can be seen to function as co-ordination tools, enabling the members of the committee to translate the contingent into the rationalistic repertoire. For example, since there are no strict mies for applying a safety factor, this allows experts to fine tune standards with ethical or policy considerations. Moreover, whereas in the mandate an ‘expert’ is a representative of a scientific specialty, DECOS members define expertise in much broader terms, including, for example, societal responsibilities and ethical judgements.

The task of the MAC-committee, responsible for the ‘feasibility’ step in the procedure, is not well defined. In practice, an approach has developed in which industry and workers’ representatives collect information on the feasibility of standards. This informal approach has later been formalized by using trade organizations as an information source. Negotiations within the committee are ritualized to enable the creation of consensus in various ways. First, since the negotiations take as their starting point the ‘health-based standard’ as defined by DECOS, and are only concerned with the feasibility of this standard, discussions on interests are objectified and lose their critical edge. Second, the immanent mies of the committee all stress the importance of reaching an agreement. For example, industry representatives perform ‘company visits’ in order to assess the seriousness of companies’ complaints.

The third ‘policy’ step in the procedure is performed by policymakers of the Ministry of Social Affairs and Employment. These policymakers, however, are active in earlier steps as well. They are a member of all of committees involved in the procedure, and function as
informal mediators for actors internal and external to the procedure. This central role gives them the opportunity to perform repair work.

From one step to another, the reports made by the various groups involved serve as intermediaries. But one should better speak of packages, because the reports written by the committees are accompanied by personal links — both consisting of policymakers, who are represented in all steps of the procedure, and by representatives of the committees in the other steps — which enable repair work.

**PRODUCTIVITY AND TRANSPARENCY — CONCLUSION AND DISCUSSION**

The possibility of productive standard setting within the MAC-procedure rests on three interrelated elements. This concerns, first, the formulation of the mandate and the organizational design, in which three domains of discretion are separated and integrated in a specific, hierarchical manner. Second, the flexibility in which the mandate can be put to use in practice, or the possibility actors have to use a contingent repertoire, which enables actors to deal with the heterogeneity of practice as compared to the homogeneity of the mandate. Last, the development of tools, that manage the co-ordination between the contingent and the rationalistic repertoire. Through these tools, domains can be represented as packages that can span boundaries between domains of discretion, while at the same time reproducing such boundaries.

A turn towards transparency can be of some danger to the productivity of the setting of MAC-values. As has been argued, the productivity of this procedure rests in large part on the flexibility in which formal rules can be handled in practice, since this allows standard setters to accommodate for the contingencies in that practice. Making the procedure more transparent, which will entail the further formalization of co-ordination tools, will restrict negotiating space and thus disable the interrelation of mandate and practice.

Rather than to stress transparency, it might be better to focus on accountability of risk assessors and managers. Whereas practices of risk assessment and management are made up of both formal and immanent rules, the latter can still be accounted for on an ad hoc basis, thus allowing both the possibility of productive translations between them, and a wider participation when needed.

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THE ROLE OF EXPERT JUDGEMENT IN HAZARDOUS FACTORS INFLUENCE PROGNOSIS: PARAMETRIC ELICITATION TECHNIQUE

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ABSTRACT
The paper presents new results in expert data processing obtained within the collaborative researches organized by the Delft University of Technology (TU Delft) and Ufa State Aviation Technical University (USATU). The main result concerns a modification of the "Delft method" for prognosis of hazardous factors influence in relation to Bashkortostan context. This methodology aims to obtain high quality uncertainty quantification and consequently to provide effective information support for decision making procedures.

INTRODUCTION
The regulation of risk for populations in industrialized areas includes
(a) the identification of hazardous objects
(b) the quantification of the hazard degrees
These tasks involve expert judgement in various ways. In particular, (b) requires the quantification of expert uncertainties as subjective probability distributions, and the combination of experts' distributions according to a suitable scheme.

EXPERT DATA PROCESSING METHODOLOGY
The expert data processing methodology developed and implemented by the TU Delft over the last 10 years is described in [1] and many further publications. The method uses generic approximations of probability densities derived from decision-maker's and experts' assessments. In this article, we focus on the following elements of the data processing:
1. Elicitation.
   This can be realized in non-parametric or in parametric forms.
   In the non-parametric case the initial information on variable $x$ to be considered is represented by the quantiles $x_{a_1}^j, x_{a_2}^j, ..., x_{a_{k+1}}^j$, which are given by each $j$-th expert $(j=1,2,...,m)$ with respect to his belief levels $a_1, a_2, ..., a_{k+1}$. In other words the $[0,1]$ interval is divided into $k$ subintervals $(\alpha_1, \alpha_2), (\alpha_2, \alpha_3), ..., (\alpha_k, \alpha_{k+1})$ where $\alpha_1 = 0$ and $\alpha_{k+1} = 1, \alpha_k < \alpha_{k+1}$.

2. The choice of the type of background distribution.
   In the great majority of applications this can be done by analyst. To support the analyst and/or to enable automatic choice of background distribution, we have extended the list of distribution types which can be processed conveniently.

3. The definition of background distribution parameters.
   Once the background distribution type is chosen, the actual background distribution is determined by specifying appropriate parameter values. For example, in the case normal parametric elicitation and normal background distribution, the background distribution parameters $\mu^*$, $\sigma^*$ can be found as
\[
\mu^* = \frac{1}{m} \sum_{j=1}^{m} \mu_j; \quad \sigma^* = \sqrt{\sum_{j=1}^{m} \sigma_j^2}
\]

where \( \mu_j, \sigma_j \) are the mean and standard deviation associated with the assessments of expert \( j \). If the elicitation is non-parametric, then \( \mu_j, \sigma_j \) must be determined from expert \( j \)'s quantiles.

4. (For non-parametric elicitation) Determination of expert densities \( f_j(x), j=1,2,...,m \).

This can be done by finding the function \( f_j(x) \) which agrees with quantiles \( x_{\alpha_1}^j, ..., x_{\alpha_{k+1}}^j \) and satisfies
\[
f_j(x) \geq 0; \quad \int_{x_{\alpha_1}}^{x_{\alpha_{k+1}}} f_j(x)dx = 1
\]

and which has maximal entropy in the class of functions satisfying these conditions.

5. Construction of the "decision-maker's distribution" \( f_{DM}(x) \).

This is realized according to expression
\[
f_{DM}(x) = \sum_{j=1}^{m} W_j f_j(x), \tag{3}
\]

where the weights \( W_j, j=1,2,...,m \), are based on expert performance on 'seed variables' [1].

6. The computing of relative information measures \( I(f^j, background), j=1,2,...,m \).

This operation requires efficient computational algorithms.

The next sections contain some enhancements to the above elements.

**ALGORITHMIC CHOICE OF BACKGROUND TYPE**

Assume that the random variable \( x \) whose distribution is estimated belongs to interval \((x^*, x^{**})\).

In particular it can be \((-+,+\)) or \((0,+\)) or any interval with finite bounds, so \( x_{\alpha_1}^j = x^*, x_{\alpha_{k+1}}^j = x^{**} \).

Let \( f(x) \) denote the background density, consequently
\[
f(x) \geq 0; \quad \int_{x_{\alpha_1}}^{x_{\alpha_{k+1}}} f(x)dx = 1. \tag{4}
\]

We can consider the individual expert distributions which are constructed of \( k \) "pieces" (with respect to \( k \) intervals for quantiles) and for each "piece" we have
\[
f_i^j(x) = C_i^j f(x), \tag{5}
\]

where \( f_i^j(x) \) is the individual density of \( j \)-th expert estimation in relation to \( i \)-th quantile interval \((j=1,2,...,m; i=1,2,...,k)\); \( C_i^j \) is the coefficient of normalization:
\[
C_i^j = \frac{(\alpha_{i+1} - \alpha_i)}{\int_{x_{\alpha_i}}^{x_{\alpha_{i+1}}} f(x)dx}. \tag{6}
\]
The relative information measure $I(f^j, \text{background})$ computed for $j$-th expert would look as follows:

$$I(f^j, \text{background}) = \sum_{i=1}^{k} f_{i,j} \int_{x_{a_i}}^{x_{a_{i+1}}} C_i^j f(x) \ln \frac{C_i^j f(x)}{f(x)} \, dx =$$

$$= \sum_{i=1}^{k} C_i^j \ln C_i^j \int_{x_{a_i}}^{x_{a_{i+1}}} f(x) \, dx.$$

Denote

$$\Delta \alpha_i = \alpha_{i+1} - \alpha_i, \quad i = 1, 2, ..., k. \quad (8)$$

Then

$$I(f^j, \text{background}) = \sum_{i=1}^{k} (\ln C_i^j) f_{i,j} \int_{x_{a_i}}^{x_{a_{i+1}}} f(x) \, dx = \sum_{i=1}^{k} \Delta \alpha_i \ln C_i^j. \quad (9)$$

The summarized relative information measure $I_\Sigma$ of the experts together with respect to background is defined as:

$$I_\Sigma = \sum_{j=1}^{m} I(f^j, \text{background}) = \sum_{j=1}^{m} \sum_{i=1}^{k} \Delta \alpha_i \ln C_i^j =$$

$$= m \sum_{i=1}^{k} \Delta \alpha_i \ln \Delta \alpha_i - \sum_{j=1}^{m} \sum_{i=1}^{k} \Delta \alpha_i \ln \int_{x_{a_i}}^{x_{a_{i+1}}} f(x) \, dx. \quad (10)$$

If we would like to choose the background type minimizing $I_\Sigma$ as a summarized measure of surprise we must maximize the second term in (10):

$$\sum_{j=1}^{m} \sum_{i=1}^{k} \Delta \alpha_i \ln \left( \int_{x_{a_i}}^{x_{a_{i+1}}} f(x) \, dx \right) \rightarrow \max. \quad (11)$$

Taking into account properties of logarithmic function, (11) may be replaced by the following condition:

$$J = \prod_{j=1}^{m} \prod_{i=1}^{k} \left( \int_{x_{a_i}}^{x_{a_{i+1}}} f(x) \, dx \right)^{\Delta \alpha_i} \rightarrow \max. \quad (12)$$

In other words it is necessary to find the density function $f(x)$ which satisfies the condition (12) under the limitations (4).

Note that in the special case when all $\Delta \alpha_i$ have the same values the requirement (12) can be reduced to more simple expression:

$$J_0 = \prod_{j=1}^{m} \prod_{i=1}^{k} \left( \int_{x_{a_i}}^{x_{a_{i+1}}} f(x) \, dx \right) \rightarrow \max. \quad (13)$$
It is interesting to consider "the physical sense" of expressions like (12), (13): we try to find the function \( f(x) \) which can be divided by the quantile values into the "pieces" whose areas' product must be maximal. This approach allows to keep the quantiles fixed, so it satisfies the requirement of experts "calibration" [1]. There are two ways to use these results for a practical choice of background measure: (I) We can use expressions (12) or (13) for direct comparisons of different distribution types (exponential, normal, Weibull, etc.) after substitution in the correspondent formula. (II) We can use any suitable approximations for \( f(x) \) (in particular, polynomial approximation), compute the integrals in (12), (13) and find the necessary measures. Either method may aid the analyst in choosing a background measure.

**Computing Relative Information**

The main problem here is to find the values of integral measures

\[
I(f^j, \text{background}) = \int \frac{f^j(x) \ln f^j(x)}{f(x)} \, dx
\]

(14)

for different types of distributions \( f^j(x) \), \( f(x) \).

This investigation has been realized within the framework of TU Delft and USA-TU cooperation.

In particular, for the normal distributions:

\[
I(f^j, \text{background}) = \ln \frac{\sigma^*}{\sigma_j} + \frac{\sigma_j^2}{2\sigma^*^2} + \frac{(\mu^*_j - \mu_j)^2}{2\sigma^*^2} - \frac{1}{2}.
\]

(15)

The values of \( \sigma_j \), \( \mu_j \) can be directly obtained in the case of parametric elicitation. In their turn \( \mu^*_j \), \( \sigma^* \) must be found from (1).

For the case of exponential distributions

\[
I(f^j, \text{background}) = \ln(\lambda_j / \lambda^*) + (\lambda^* - \lambda_j) / \lambda_j,
\]

(16)

where \( \lambda_j \) is a distribution parameter value given by \( j \)-th expert;

\[
\lambda^* = m / \left( \sum_{j=1}^{m} (1 / \lambda_j) \right).
\]

(17)

The correspondent expressions have been obtained also for gamma and Weibull distributions. These results give a possibility to estimate "discrepancy" between the experts' and background densities and finally to formulate the conclusions regarding the quality of uncertainty quantification.

These developments have been implemented in a code REXCALIBR [2] which is a research test bed of shareware package EXCALIBR initially created at TU Delft.

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ELICITING EXPERT JUDGMENT ON HEALTH AND ENVIRONMENT IN THE HEALTH COUNCIL OF THE NETHERLANDS

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ABSTRACT
The Health Council of the Netherlands, founded in 1902, advises the Dutch government and parliament on matters of health. Its reports are prepared by autonomous, multidisciplinary ad hoc committees appointed by the President of the Council. In the past twenty years or so the relationship between environment and public health has been the focus of many of them. The Council has issued reports on subjects such as guidelines for risk assessment, risk assessment of ionising and non-ionising radiation, noise and many (groups of) chemicals, including endocrine disruptors. Although the committees have been central to the advisory process, in special cases modifications have been introduced to smooth the drawing up of reports, such as holding interviews and workshops, consulting foreign experts and stakeholders. We discuss the strengths and weaknesses of the adopted alternatives, illustrating them with examples.

INTRODUCTION
The Health Council of the Netherlands (Gezondheidsraad) has a long history. It has existed in one form or another since 1902, with the Health Council in its present form established by the 1956 Health Act. The Health Council is a statutory advisory body to the government. The Health act of 1956, amended in 1997, defines the Council's duties as follows: '...to advise the government and Parliament on the current level of knowledge with respect to health issues...'. The Council never meets in plenary session. Its reports are prepared by autonomous multidisciplinary ad hoc committees appointed by the President of the Council. In most cases, the committee is required to answer ministerial queries. However, the Council also has the authority to issue advisory reports on its own initiative. Committees consist of both Council members and external experts. Within the Health Council, there are eight standing committees, each of which deals with a broader subject area than those covered by the ad hoc committees. The standing committees review draft committee reports and bring topics to the fore which merit Health Council assessment. As such they are involved in the preparation of the Council's work programme. One of them covers the area of health and environment, the importance of which has increased due to enhanced interest of society in health risk analysis. Most advisory reports in this field are addressed to the Minister of Health, Welfare and Sport, the Minister of Housing, Spatial planning and Environment or the Minister of Social affairs and Employment.

Health Council committees assume responsibility for most of the reports; these have the statutory character of an advice to the government. A recent example from the field of health and environment is 'Lead in drinking water' (1). Some Health council reports are so-called background documents, reviews compiled by members of the scientific staff or consultants and published by the Council. 'Risk assessment of peak exposure to genotoxic carcinogens' provides an example (2). The purpose of this type of report is to compile the knowledge on a subject related to the Council's work programme.
VARIANTS
The deviations from standard working procedures vary. The simplest is the consultation of additional experts (3,4). They can attend a meeting of the committee or be interviewed by staff. This is a practical solution when during preparation of the advisory report it appears that supplementary knowledge is required.

Another approach is to combine a background report and the proceedings of a workshop as input for a committee preparing an advisory report. This was the approach taken to report on indoor air quality and respiratory problems (5). A staff member wrote a background document, organised an international workshop during which the most important issues resulting from the survey were discussed, and a Health Council committee used the workshop proceedings as the basis for its report. Background document and workshop proceedings were included in the report as annexes. This procedure is suitable when opinions vary to a large extent. It requires extensive staff work before the start of the committee, but saves time in the phase of drawing up the advisory report.

A slightly different variant starts with consultation of several experts, followed by a workshop, and finally, appointment of a committee selected from among the participants. In the example presented the committee had the task to answer the question whether endocrine disruptors constitute a direct, acute threat to public health (6). The actuality and the concern among scientists and in society in general made the President of the Health Council to choose this variant.

A problem for the Health Council is that the Netherlands are a small country and not all fields relevant to the area of health and environment are covered by Dutch experts. The simplest manner in which the problem has been solved is by appointing committee members from neighbouring countries who speak our language (7). It is easily organised and not too expensive.

Another solution is to assemble an international committee. This option was chosen in the case of the uniform environmental noise exposure metric (8). First the committee members were interviewed by staff to determine priorities for consideration and to determine criteria for a focussed literature review and analysis of the information gathered. The staff subsequently prepared a draft that the committee discussed at two meetings. This approach has several advantages in addition to the filling of gaps in expertise. An international committee has a broader basis and its product is more easily accepted in international policy debates, e.g. at the EU level. This is a relevant aspect when, as in this case, the subject has EU-wide importance.

In cases of widespread public concern, such as about the health risk of mercury leaking from amalgam tooth fillings, stakeholders can be heard (9). In the case of amalgam and other toothfilling materials this was done by inviting organisations of amalgam opponents to bring to the fore publications that the committee should take into account. An annex to the advisory report contains the committee's evaluation of each of the publications presented.

International workshops have also been held to discuss complex and controversial subjects, for instance 'health effects at low exposure levels', and to create a forum for discussion between American and European scientists of an American advisory report on diet and cancer (10, 11). In this case the purpose was to avoid double work and to determine the relevance of
the conclusions in a European context. The proceedings of the former were published together with a short statement of the Council's President directed to several ministers, because the matter remained elusive. Those of the latter were published separately.

When similar questions have to be answered in succession, a permanent committee is the best option. This course has been chosen for health risk assessment of series of chemicals. The Committee on Risk Assessment of Substances reviews criteria documents published by the National Institute of Public Health and the Environment. The committee has a core of permanent members and for each document ad hoc compound-specific experts are added. The Dutch Expert Committee on Occupational Standards (DECOS), another permanent committee of the Health Council, also deals with chemicals, but concentrates on compounds of occupational relevance. In most cases this committee does not give a second opinion on documents, but publishes a criteria document on its own behalf. The first draft is prepared by a consultant by contract with the Ministry of Social affairs and Employment. Draft reports of DECOS are published to obtain public comment. The major advantage is that the evaluation of the committee, including a recommended health-based exposure limit, is rarely challenged in the stage of regulatory decisions. The Committee on the Evaluation of the Carcinogenicity of Chemical Substances was appointed to prepare guidelines for the evaluation of chemicals for carcinogenicity and to support the first-mentioned committee with regard to this aspect of risk assessment. Recently the committee's duty was limited to answering questions on the carcinogenicity in complex cases. The reader is referred to another paper in this volume for the position of carcinogenic properties in toxicity and risk assessment. The most prominent advantages of permanent committees are the consistency among their reports and their efficiency due to familiarity with the type of problem to be solved and range of solutions. However, up to date functioning must be ensured by adding new members to replace experts that stepped down and experts covering novel fields considered an asset.

More recently aspects from working procedures mentioned above were combined in an international committee appointed to update the risk assessment of a list of chemicals from the occupational field within a certain time frame. This combines consistency, a broad international basis and speed.

CONCLUSIONS
The overview of working methods of the Health Council is not limitative; only the most prominent ones have been presented. We consider the flexibility in the activities of the Health Council an essential element of scientifically sound advice to the government and Parliament. The flexibility is also important due to the international dimension, now that the EU has taken over many responsibilities from its member countries. It is, at least partly, driven by the intent to avoid repeating high-quality work of others.

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QUANTIFICATION OF EXPERT OPINION ON RISK FACTORS FOR BOVINE RESPIRATORY DISEASE IN DAIRY YOUNGSTOCK IN THE NETHERLANDS

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INTRODUCTION
'Bovine Respiratory Diseases (BRD)' are important to the dairy industry, especially to the rearing of youngstock, because of the losses associated with both treatment and reduced performance of the affected animals. Insight into the risk factors for BRD can help farmers to improve their rearing system in attempting to decrease the incidence of the disease on their farms. Risk factors for BRD in dairy youngstock are investigated in several studies (among others: Curtis et al., 1988; Sivula et al., 1996), but the results of these studies vary widely. In addition, the majority of these studies might not be relevant to dairy youngstock in the Netherlands because of the differences in rearing conditions. To review and complement the data that are available from literature, useful information can be obtained by eliciting expert opinions and experiences (Cooke, 1991; Meyer and Booker, 1991). This paper describes a study aimed at the elicitation of expert information with regard to risk factors related to the incidence of BRD in dairy youngstock in the Netherlands. The focus of this study was on identifying and ranking the most important risk factors for the disease.

MATERIAL AND METHODS

Expert consultation
An expert panel was composed consisting of 21 persons who had been working in the field of BRD for several years. The total expert consultation consisted of five different rounds and included four rounds held by mail followed by a one-day workshop (round 5). In rounds 1 to 4 the so-called Delphi procedure (Cooke, 1991; Meyer and Booker, 1991) was used to reach consensus among the experts on the various subjects considered. The Delphi rounds focused on qualitative aspects of BRD, especially the definition of BRD, classes to be distinguished with respect to BRD type, severity of disease and age of youngstock, and the definitions of each of these classes. Different types of BRD, disease and age classes were distinguished because the incidence and/or risk factors of the disease were expected to differ between the various classes. Furthermore, the experts were asked to define, select and rank the most important risk factors for the incidence of BRD. They were asked to do so for six different combinations of BRD type, age and disease class ('BRD combinations') that were considered most relevant, separately.

During the workshop, the relative importance of the various risk factors (levels) in each of the six BRD combinations considered was estimated using computer-supported questionnaires based on the so-called 'Adapted Conjoint Analysis (ACA)' method (Metenagro, 1994). ACA is founded on the principles of conjoint analysis, a questionnaire technique frequently used in marketing and consumer research in order to elicit consumers' preference for a product (Green and Srinivasan, 1990). Products are thought of as possessing specific levels of defined attributes or characteristics. A respondent's judgement for a product is modelled as

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the sum of the respondent’s preferences for each of the product’s attribute levels (Steenkamp, 1987; Metenagro, 1994). Respondents are asked to rank or rate several ‘profiles’ or product concepts and, afterwards, regression analysis is used to decompose the total scores given to these profiles in order to estimate the relative importance of the different attributes. In other words, the total score of each profile is broken down into its components belonging to the separate attribute levels. These scores indicate the influence of each attribute on the respondents’ overall preference for a particular profile. In the context of this study, a profile stands for a farm situation with attributes in this case representing risk factors that are related to the risk of BRD. The experts were asked to judge these profiles as to their expected impact on the incidence of BRD on the farm.

The term ‘adaptive’ of ACA refers to the process of adapting the interview for each respondent, which minimises the number of questions and the time required to complete the survey while still sufficient attention is given to those attributes the respondent considers most important (Metenagro, 1994).

An ACA interview consists of several sections, each with a specific purpose, which proceed each other in a fixed order. The information gained in the last section is used to calibrate the respondents’ preference values and to calculate the internal consistency of the answers given by the individual respondent. The consistency is expressed by the correlation coefficient $R^2$ that varies between 0 (very inconsistent) to 1 (very consistent) (Metenagro, 1994).

A different ACA questionnaire was drawn up for each of the six BRD combinations considered. Each of the 20 experts that participated in the workshop was given two different ACA questionnaires. The questionnaires were distributed among the experts so that the relative importance of the various risk factors for each of the six BRD combinations was estimated by about the same number of experts (six to seven). The participants completed the self-explanatory ACA questionnaires individually and independently from each other. The ultimate output of an ACA interview consists of the experts’ estimates on the relative importance of the various risk factor levels.

**Analyses**

The relative importance values of the various risk factor levels provided by ACA were evaluated for each BRD combination separately. First, these values were standardised so that they could be compared among the different experts, and converted to percentages. Next, the median relative importance value (percentage) of all experts was calculated for each risk factor level. The risk factors then were ranked based on the relative importance (median value) of the level (of that risk factor) that was considered most important (i.e. had highest median value).

**RESULTS**

BRD was distinguished to two types, being pneumonia and ‘outbreak cases’, and three disease classes, being mild, severe and chronic. Furthermore, youngstock was divided by the experts into the following three age classes: 0-3 months, 3-6 months and 6-24 months.

The median correlation coefficient of the 39 ACA questionnaires that were completed during the workshop was 0.86. All 32 questionnaires that had an $R^2 \geq 0.6$ were included in the analyses.

Table 1 presents the (median) relative importance values (expressed as percentages) and the ranks of the risk factors of two of the six BRD combinations considered during the workshop,
namely for mild and severe pneumonia in calves aged 0-3 months. From this Table it can be seen that the relative importance values of the risk factors for severe pneumonia, ranging from 3.5 to 15.7%, varied more than for mild cases of this disease which ranged from 8.2 to 14.1%. The two risk factors that were considered to increase the incidence of pneumonia in dairy calves aged 0-3 months most (rank 1 and 2) were air circulation and housing system for mild cases, and purchase of cattle and colostrum management during the first day of life for severe cases, respectively.

Table 1. Median relative importance values (expressed in percentage) and ranks of risk factors for both mild and severe pneumonia in dairy calves aged 0-3 months ($R^2 \geq 0.6$, $n=4$ for mild and $n=6$ for severe cases)

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Mild cases</th>
<th>Severe cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Importance in % (min-max)</td>
<td>Rank</td>
</tr>
<tr>
<td>Air circulation</td>
<td>14.1 (4.4-19.1)</td>
<td>1</td>
</tr>
<tr>
<td>Housing system</td>
<td>13.8 (8.5-17.2)</td>
<td>2</td>
</tr>
<tr>
<td>Density</td>
<td>10.8 (0-17.3)</td>
<td>3</td>
</tr>
<tr>
<td>Group size</td>
<td>10.2 (0-18.7)</td>
<td>4</td>
</tr>
<tr>
<td>Season of birth</td>
<td>9.5 (4.9-26.1)</td>
<td>5</td>
</tr>
<tr>
<td>Colostrum management during 1st day of life</td>
<td>8.8 (5.9-12.4)</td>
<td>6</td>
</tr>
<tr>
<td>Bedding condition</td>
<td>8.4 (1.7-12.2)</td>
<td>7</td>
</tr>
<tr>
<td>Purchase of cattle</td>
<td>8.2 (4.9-17.0)</td>
<td>8</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION

In this study, the cut-off value of the correlation coefficient of 0.6 was chosen arbitrarily. However, the results were very similar to a higher cut-off value (results not shown). Van Schaik et al. (1998) used a cut-off value of 0.3 and reported no significant differences in their results increasing this value to 0.5. So apparently, increasing the cut-off value has only a minor influence on the outcomes, at least not for small changes. The overall median correlation coefficient in this study was high, both absolutely and relatively to previous studies (Stärk et al., 1997; Van Schaik et al., 1998). The experts' answers being very consistent may be due to the fact the experts experienced the duration of the interviews not (too) long, the risk factors to be defined well and the profiles very realistic (evaluation results not shown). The high correlation coefficient may, at least partly, also have been caused by the very extensive Delphi rounds held prior to the ACA interviews. Besides the fact that because of the Delphi procedure the risk factors and other aspects of BRD were clearly defined, this indirectly resulted in the experts being confronted with and reflecting upon their opinions on aspects related to BRD many times. This will have helped them to prepare a well-defined view on the subjects.

The procedures and methods applied in this study together with the high consistency have led, although based on a small number of observations (per BRD combination), to an accurate identification and ranking of the perceived risk factors of BRD in dairy youngstock in the Netherlands. Of course, the importance of the risk factors as perceived by the experts may be different from its true impact. However, it is very difficult, although not impossible, to obtain

*the complete overview of the results can be obtained from the first author.
the truth, i.e. the ‘gold standard’, concerning the importance of the risk factors of animal diseases. The use of expert opinion is thought to be of good value complementary to field studies and experimental research, and can be used, among other things, to indicate the areas of interest for further research. In addition, the insight gained in this study, may be very helpful to dairy farmers and their veterinarians, as it provides them with useful information in the decision-making process on farm management practices in attempting to decrease the farm-level risk and/or incidence of BRD.

ACKNOWLEDGEMENTS
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SCIENTIFIC ADVICE AND PUBLIC DECISIONS
RECENT INSTITUTIONAL RESPONSES IN FRANCE

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ABSTRACT
The need to formalise risk assessment procedures has been recognised long ago. The 1983 report of the US Academy of Science played a key role in this process by raising many issues that are still discussed. Where are the boundaries between assessment and management? Between analysis and decisions? What are the roles of authorities, scientific institutions, expert bodies, industry, elected representatives and so on?

In France, in the last two years, numerous changes have taken place and many are still underway in the field of food risk, environmental health issues, risk from medical products, nuclear industry and radiation risk. Laws have been adopted and governmental or parliamentary reports have been issued which provide an interesting material that illustrates how the above questions have been answered in those areas.

For example, in nuclear safety it was recognised that a national institute for expertise was needed, independent both from the operators and from a regulatory agency, agency which responds to the department in charge of such affairs. In food safety, an agency was created, whose role is limited to assessment, including assessment of the action of the administration. Regarding the safety of products used in medical practices (drugs but also prostheses...) an agency was also created, whose actions encompass regulatory decisions, and where individual experts are called upon to participate to commissions.

On the basis of an outline of the various functions associated with regulation, assessment and industrial production, a comparative analysis is performed. It illustrates that different institutional schemes can be set up which all of them have positive and negative aspects. The factors that led to such differences are searched for. This comparative approach is useful when looking at the possible improvements of institutional responses.

INTRODUCTION
In France, as in the European Union, major regulatory evolutions in the area of risk, took place at the end of the seventies. At that time the concern was to keep under control the risk from hazardous facilities, in the aftermath of Feyzin (Fr), Flixborough (UK) and Seveso (I) accident. In addition such an issue was considered as a rather technical one, that may be handled, provided the owner of the facility performs a proper risk assessment study and provided the authorities ensure an adequate enforcement of regulation.

Since that time, new issues have arisen (B.S.E., AIDS, contaminated blood...) and approaches for risk management and assessment have evolved. Discussions on boundaries between assessment and management have evolved further, and so did proposals about the involvement of elected representatives and interested parties. The present paper aims at the
description of the ongoing changes in France, with a view to illustrate a series of possible institutional approaches to the control of risk.

**RECENT WORK**
The involvement of members of the parliament, of other elected representatives and political people in the design of institutional responses to risk issues is not new in France (e.g. radiation wastes). However, it has been especially important in the last two years and many areas have been addressed. Among initiating events one may quote traditional issues like nuclear safety, but also affairs of international (Mad Cow, Genetically, Modified Organisms) or more national (Asbestos, AIDS contaminated blood) relevance. In the case of AIDS contamination due to uncontrolled blood transplant, a special court has been designed for the trial of three ministers (including the prime minister) in charge at the time of the event, which is an unprecedented procedure in France.

In spite of bitter controversies, there was a consensus on the fact that the way decisions can be taken at the state level deserve in depth analyses. The year 1998 was eventful. On demand of the prime minister the head of the Parliamentary Office for the Assessment of Scientific and Technical choices issued a report on Radiation Protection and Nuclear Safety [1]. Ministerial discussion followed and law on Nuclear Safety and « Transparency » has been prepared, and is still under discussion. Still on demand of the Prime Minister, two the members of the Office, have prepared a report on Environmental Health Safety [2]. An « Agency for Environmental Health and Safety » is under discussion now. Last, a law dealing with Health Vigilance and Health and Safety of Products for human use (i.e. at the same time food, drugs and other medical products). The law created, inter alia, an Institute for Health Vigilance, an Agency for Food Health and Safety, and an Agency for Health and Safety of Medical Products.

**FRAMEWORK FOR A COMPARATIVE ANALYSIS**
Obviously enough, many features of the above mentioned development and criteria are very dependent on the French context, and more precisely, in the specific area under consideration. Nevertheless, at the same time, common issues have been addressed:

- How to organise an « independent » decision making process (independent from industry and operators, from political power...)?
- How to ensure that scientific evidences and expertise are made available to the decision makers and to interested parties?
- How to avoid confusion between assessment and decision?
- How to involve the public and interested parties in the decision, or at least how to guarantee the traceability of decisions?

When reviewing proposals and actual organisations, three basic functions were identified:

- regulation, which may include licensing, authorisations control, monitoring and various agreements;
- expertise, which may apply to the assessment of specific cases, generic risk assessment and to the development of related research;
- operation, which encompass commercial or industrial activities, but also self monitoring and internal risk assessment.

The roles of the various agencies and national administrations were examined with respect to the functions they fulfil and with respect to the way questions about independence, expertise build up or involvement of interested parties are answered.
The present analysis focused on the national level. It is indeed a limitation, especially as regards involvement of interested parties in the case of industrial objects, but it is not when food and drug issues are dealt with.

**SOME APPROACHES IN VARIOUS AREAS**

In the case of Health and Safety of Food, the three functions correspond clearly to three different bodies of actors. The regulatory function is performed by classical administrative bodies at the national (prohibition, rules and licensing) and local (control and monitoring level). The Agency for Food Health and Safety, made up from existing research institutes, is plainly in the expertise field, with a strong asset in research. Expertise encompasses the assessment of policies of the administration. As regards operators, they correspond to very heterogeneous activities (agriculture, food industry, commercial activities (commerce), restaurants...), but the importance of self control must be underlined. Independence with respect to the political power and involvement of the public were questioned when the law was issued.

Health and Safety of Products for Medical use is dealt with in the same law, but in a quite different way. The apparent similitude in the vocabulary is deeply misleading. An Agency was created too, with a similar title (Agency for Medical Products Health and Safety), but it rather fulfils a regulatory function, on behalf of the administration which maintains a remote responsibility. Expertise function is organised within the agency through ad hoc expert groups, whose individual members come from all sectors. There is no specific institute devoted to this expertise. An aspect body has been also build up, the Institute for Health Vigilance, but its role is more generic. Its deals with public health assessment but not specifically with regard to medical products; food-related diseases, exposure to radiation’s and carcinogen at the work place or in the environment. In contrast with the case of food safety it is the distance between regulation and political responsibilities which has been criticised, as well as the way expertise and decision are interrelated.

Nuclear Safety is an other area where existing organisation deserves to be described. Here, as in the case of food safety, regulatory and expertise roles are clearly separated, with a ministerial administrative body in charge of regulation, and an institute for expertise strongly involved in research activities. Some specific features are interesting ; the expertise activity for the regulatory bodies is very explicitly stated and monitored and it is financed by a tax on facilities. Advisory groups are build up, which are more and more open to various interersted parties. This system was criticised because the independence of the expert organisation was felt insufficient (it belongs to the Atomic Energy Commission), because the regulatory body was felt to be too dependant on the government, because radiation protection (which actually is not a matter of concern only in nuclear installations) was not organised in a way consistent with safety and because of doubts on openness of the system. Following the report on this question, autonomy of the expert body has been decided, as well as the design of a regulatory agency with a very large autonomy. Interestingly enough the last proposal was felt not acceptable by a court, because it erased the responsibility of the government and elected people. As regards openness, it has been mentioned in the title of the law under preparation on nuclear safety.

In the field of environmental safety, the proposals are still under discussion, with the possible build up of an agency for Environmental Health and Safety. The need for separation between
assessment and decision is strongly stressed in the report, as well as the effort that are necessary for a better participation of interested parties.

CONCLUSION
This short survey illustrates how key principles (e.g. independence of regulatory bodies, separation between expertise and decision) have been dealt with in various areas. The differences between the answers that were given, and the criticisms that were made (and contradictions in those criticisms) illustrate that clear principles cannot be easily applied, and that whatever the solution, drawbacks can be found (e.g. if a regulatory body is totally independent from the government, then people elected by the citizens are not responsible anymore). It is believed that such comparisons are helpful in identifying positive and negative aspects of various institutional schemes so that related decisions can be better grounded.

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ABSTRACT
The quantification of uncertainty associated with the assessment of industrial accident consequences is in the focus of risk analysts' attention. The use of expert judgement results in order to represent this uncertainty in subjective probabilistic codes requires the development of corresponding software applications for data processing.

The authors present a universal data processing software application REXCALIBR which aims to realize some effective procedures for expert judgement treatment. At the same time it is an enhancement of the shareware package EXCALIBR initially developed at the Delft University of Technology.

1. Decision-making process: the role of software application. The main aim of REXCALIBR is to help analysts and decision makers in their work using methods of expert judgement. Figure 1 shows generic structure of decision-making process. An analyst considers a problem and after that he transforms the problem into a task for REXCALIBR application. In other words the analyst formalizes the problem by means of software "language" in order to use its mathematical modules. So REXCALIBR can be utilized as decision-making support system.

Fig. 1
The most important modules and internal interaction structure of REXCALIBR application are illustrated by Figure 2. Since an analyst has divided a problem into some tasks he can form a list of items (questions) for experts. The item list must be full enough to characterize the problem completely. On other hand, items should not be too complicated, so the experts could answer them. Some items must correspond to realizations in order to calibrate experts.

In the next step the analyst chooses experts which are able to estimate these items. The analyst can use a database for experts if such database exists. The experts assess the items, and experts' assessments and item realizations have been put to REXCALIBR database.
REXCALIBR makes data processing and computes resulting assessment. It is called decision-maker's assessment (DMA). The analyst can optimize DMA via optimization module. In this case analyst have to set optimization parameters.

Finally the analyst must choose the best decision-maker's assessment.

Fig.2

2. REXCALIBR methodology for the expert judgement. Expert judgements in the REXCALIBR application are cast in the form of subjective probability distribution [1]. Subjective probability can be taken as (1) non-parametric elicitation or (2) parametric elicitation.

1) In this case subjective probability measures degree of belief with respect to possible observations. Hence experts are asked only about physically observable quantities. Degree of belief is elicited in the form of some (for example, 5%, 50%, 95%) quantiles of subjective probability distributions. The 5% quantile of the distribution for uncertain quantity \( X \) is the number \( x_5 \) such that

\[
\text{Prob}(X \leq x_5) = 5\%
\]

2) Parametric elicitation requires the estimation of distribution parameters. For example, experts assess expectation and dispersion for normal distribution; exponential distribution is judged in relation to \( \lambda \)-parameter.

REXCALIBR data processing methodology is based on the theory of proper scoring rules. "Calibration" and "relative information" are the main concepts in this model. The calibration shows the degree to which the actual measured values correspond, in a statistical sense, with
expert's assessments. In other words, the calibration scores depend on the statistical likelihood of expert's assessments, the given realizations of the seed variables. The relative information can be considered as a measure of surprise of someone who believed the background probability and subsequently learned the probability based on expert's assessments. For calculation of the relative information measure it is possible to use the background distributions of different types (uniform, loguniform, normal, exponential, Weibull's distributions [2]).

The weights of experts which can be used to obtain DMA by means of this method are proportional to the product of the calibration and of the relative information. The calibration dominates over the relative information, so that an expert with high relative information and poor calibration will not receive a substantial weight. A resulting decision-maker's assessment is computed using the normalized weighted linear combination of the experts' distributions. The theory of proper scoring rules requires that there should be a non-zero "critical level" (i.e. a such level that an expert receives zero weight if his calibration falls beneath this level). The actual level to be used is defined by optimization. If \( N \) experts receive distinct calibration scores, then \( N \) different possible "decision-makers" are generated and the level is chosen successively higher. At the lowest level all experts are weighted, at the highest level only one expert is weighted. The possible decision-makers are scored by taking the product of the calibration and information scores, and that level is chosen for which the decision-maker's score is the highest. The decision-maker generated in this way is called the "optimal decision-maker". The optimization function is "calibration\( \times \)information" under the constraint that the experts' unnormalized weights satisfy the requirements of strictly proper scoring rules.

3. **Software specific features.** REXCALIBR is able to operate data for more than 1000 experts and for more than 1000 items. For non-parametric elicitation experts can assess until 99 quantiles.

REXCALIBR allows:
- to create and to reuse databases of experts and experts' assessments;
- to organize three levels of input data control;
- to give the graphical illustrations for all obtained results;
- to represent the results of computation within framework of Microsoft Office using special parallel sessions.

Comparison of decision-maker's and experts' results can be done directly with respect to the assessment value. The approximations of probability densities and integrated histograms obtained from decision-maker's and experts' assessments are also supported.

Finally it is necessary to conclude that REXCALIBR becomes an effective application which allows for wide category of users to form the decisions based on expert judgements.

**ACKNOWLEDGEMENTS**
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Policy Assessment, Goal Setting, Health & Public Policy
RISK-BASED REGULATION: A SUITABLE CONCEPT TO LEGISLATE AND REGULATE TECHNICAL RISKS? EVALUATION OF VARIOUS CASE STUDIES IN SWITZERLAND

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ABSTRACT
The approach of risk-based regulation (RBR) wants to make law more efficient. Its aim is to replace prescriptive, deterministic regulations by goal-oriented, probabilistic regulations, based on the criteria of cost-effectiveness and limitation of individual risks. The overall goal is to achieve more safety at less costs. The approach is theoretically convincing and economically reasonable. Its practical implementation, however, raises a lot of technical and legal questions. The project "risk-based regulation" (1996 – 1999) intended to evaluate the practical feasibility of the approach from a technical and a legal view. In this perspective, nine case studies were carried out, i.e.:

- Storage and management of explosives (both military and civil)
- occupational safety
- non-occupational accident prevention (mainly road accidents)
- fire protection
- transportation of dangerous goods
- waste disposal (conventional toxic landfills and radioactive repositories)
- nuclear (reactor) safety

The project outline and programme including some basic bibliographical notes were presented at the SRA-E Conference in Paris last year [1]. This paper evaluates final results [2] of the case studies and gives some answers to the following questions:

- To what extent is a risk-based approach both legitimate and practically feasible?
- What are the legal questions raised in connection with the approach?

Based on the evaluation of the case studies, general conclusions are drawn on the possibilities and limitations of implementing a risk-based approach.

1. INTRODUCTION
The existing law system is based on various regulating strategies to limit technical risks. Frequently it adopts a deterministic approach by prescribing precise measures whose execution is relatively simple: It can unambiguously be determined whether the set goals are reached or not. This, however, does not necessarily assure an optimum safety level. In addition, different technical fields are not homogeneously treated. The consequence is inefficiency: Invested financial and other means do not result in optimum safety and protection of environment. These discrepancies have called for an approach which is more coherent and more efficient.
2. RISK-BASED REGULATION: CONCEPT AND APPROACH
The risk-based approach aims at eliminating the mentioned deficiencies by being:

- goal-oriented: Law shall not prescribe punctual safety measures but determine quantitative maximum permissible risk levels. The responsible parties are free by which means they are up to meet the requirements.
- standardized: RBR permits a regulation of heterogeneous risks according to comparable criteria.
- probabilistic: The approach assumes that risks can never be completely eliminated but optimized. It puts up with risks but tries to limit them according to rational criteria.

There is a distinction between the direct and the indirect application of RBR:

- Directly applied, particular cases are evaluated as to specific protection goals. The risk of the activity looked at has to be quantified and compared to the respective protection goal.
- With an indirect application, RBR is followed in the sense of a directive or an evaluation criterion for a prescriptive legal decree. The requirements are framed in a way that the result is the adherence to the protection goals.

Protection goals are determined by way of two criteria (two-fold criterion):

- An individual risk limit protects individuals from undue risks.
- A (marginal) cost-effectiveness criterion serves as a limitation of the collective risk and as an economically optimum allocation of resources. It ought not to be confounded with risk-benefits considerations since the target is not whether or not to build or retain an installation but to evaluate certain additional safety measures.

Therefore the risk limitation follows from two rules:

**Rule 1:** The individual risk resulting from a risk source and laid upon the most exposed individual has an upper limit of $10^x$ per year.

**Rule 2:** In addition, the risk is to be reduced in so far as the costs of the risk minimizing measures are lower than $y$ monetary units per reduced risk unit.

In theory, the protection goals could be satisfactorily determined by the definition of both values $x$ and $y$. This, however, would not account for the fact that risks have to be appraised according to whether they are undergone voluntarily or not, to the degree of risk information, avoidability, influenceability or perceived benefit. This can be dealt with differentiating values of $x$ and $y$. In Switzerland, four such categories with varying values have been proposed:

**Category 1:** voluntary risk exposition in order to satisfy one's own desires, e.g., dangerous sports

**Category 2:** high degree of self-determination, direct individual benefit, e.g., car driver

**Category 3:** low degree of self-determination, individual benefit, e.g., worker

**Category 4:** involuntary, imposed risk exposition, no direct benefit, e.g., local residents of a dangerous installation

Depending on the category we propose limits of $10^{-5}$ to $10^{-3}$ per year for individual fatal risks. As to risk reducing measures, the human capital values for marginal costs are set to 1 to 20 MCHF per year and life saved accordingly.
The minimum goal was to develop proposals if necessary for a more efficient legislation and regulation in each technical field of the respective case study. The maximum goal was to propose an overall concept for all technical risks under consideration.

3. RESULTS

Swiss law not systematically risk-based
There are various requirements which prescribe inefficient safety measures. Overall, there is no standardization nor quantitative determination of safety criteria though, in some areas, the law in force is directly or indirectly risk-based (road transportation of dangerous goods).

Methodology with two-fold criterion proved to be valuable
In average, analytically the individual risk can be reliably quantified with larger groups. Problems arise in the following circumstances:

- The mechanism is more difficult the smaller and more specific the affected group is. The protection aimed at is not achievable for highly exposed individuals.
- If the risk is not reliably quantifiable it may be demonstrated that it does not exceed a certain limit. By this means, however, a strongly conservative element is built in.
- If the individual risk results from multiple risk sources (e.g., road traffic) it stays unsolved who has to take risk reducing measures. This must be determined via specific rules (cf. air protection action plans if immission limits exceeded). Not to violate the polluter pays principle, the polluter would have to be liable for the necessary costs.
- Where other than personal risks are decisive (e.g., environmental risks), absolute risk limits have to be set by other means.

As to the marginal cost criterion, the collective risks are for most cases well quantifiable. Problems still exist as follows:

- In some cases like reactor safety the quantification of collective risks are bound to considerable uncertainties. Meaningful statements on absolute cost-effectiveness are restricted.
- Risks other than fatalities, like environmental risks, may be quantified where they are relatively small and well known (e.g., accidents in the transportation of dangerous goods). For conventional toxic landfills, contaminated sites, radioactive repositories and nuclear reactor accidents the environmental risks cannot be quantified with sufficient reliability.
- In some areas difficulties arise with regard to expenses and the effectiveness of risk reducing measures, not so much due to the quantification of collective risks.

At any rate, even if sufficient quantification is lacking, probabilistic risk analyses can provide a good system understanding and are useful for the identification of weak spots and problems. They explicitly address types of uncertainty (variability, data deviation, model and scenario issues). As such they are a systematic decision tool for a transparent risk appraisal.

RBR may only be applied directly with special objects which are outstanding with regard to risk and economical significance. With other installations an efficient direct application assumes standardized procedures. In all other cases the approach has to be indirect.
Comparability of technical fields possible—with some restrictions
In principle individual risks may be compared irrespective of the type of risk source. Restrictions are given where
- risks other than individual risks are decisive (environmental, catastrophic)
- the risk specific reference frames are not comparable since individual risks always draw
  upon particular reference quantities (per year, per average member of a group, etc.).
These reference problems may be solved by way of the marginal cost approach since this
criterion does not rely on a direct comparative risk analysis. Qualitatively comparable are the
risks in the following areas: military and civil explosives, occupational as well as non-
occupational safety, and fire protection. There is no evidence why the same standardized
safety criteria should not be applied to other risk areas with similar qualities like construction
safety, electrical installations, railways, air and naval traffic as well as product safety.

In the case of qualitatively heterogeneous risks it is more difficult to formulate standardized
protection goals—due to technical and political reasons. This argument is valid where
- the damages are distinctly different, e.g., human vs. environmental (cf. landfills and
  contaminated sites), where the relative weighting of single indicators is highly sensitive
  (e.g., transportation of dangerous goods)—a limitation to certain proxy indicators is biased
- different time horizons occur, e.g., immediate vs. long-term risks (cf. nuclear repositories)
- large events are significant, e.g., low probability-high consequence risks (cf. reactor safety)
- the cost-effectiveness of specific areas cannot be quantified.

Improvement of efficiency
The efficiency of the technical safety law could be raised in areas with quantifiable risks. Usually
measures adequate in a safety perspective are also economically advantageous. Mostly even then individual risks could be lowered. At the time being, we cannot make a
valid statement on the efficiency at an overall economical scale.

Support for proportionality and equality principles
With RBR the legal maxims of proportionality and equality may be better comprehended. The
democratic and legal steering mechanisms may be improved. It is not conceivable that the
approach as such leads to a technocratic usurpation of political decisions.

Some specifics
In fields where applied (e.g., explosives) the two-fold criterion approach has proved valuable.
If a potentially affected population is very young or very old absolute risk criteria do not make
sense; they should be related to life years. In case of uncertainties, the deviation types (not the
means) should be drawn upon in order not to violate the precautionary principle. As for large
events, indicators other than death have to be considered (system damages, vulnerability).

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RISK MANAGEMENT IN MEDICINE AND HEALTH.
ADVOCATE FOR A TWO THRESHOLD-THREE LEVEL GUIDELINES

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ABSTRACT
Recommendations or guidelines aim at an improvement of appropriateness between diseases and treatments or more generally between conditions and interventions. The choice of an intervention is always a dichotomous choice: to perform or not. The nature, qualitative or quantitative of disease is an old dispute, but still existing. If some "diseases" are quantitatively define like hypertension some others are more qualitative (Measles, Huntington disease for exempla). But whatever a disease is quantitative or a qualitative condition, risk is essentially a quantitative concept. Therefore guidelines for risk management face the problem of how to cope with on hand a dichotomous choice and on the other a continuous risk curve. Guidelines makers however have to take decision; indeed no decision is a decision. Guidelines are needed to avoid the development of variable medical practices i.e. two person in the same condition being offered different treatment. Discretionary threshold (unfit) is assumed to be better than heterogeneity (inequity). The determination of the threshold is discretionary but not arbitrary, meaning that expert choose a breaking point on the curve within a range of plausible value define by efficacy analyse, risk-benefit analyse, cost-benefit analyse. The clue for the discretionary nature of the choice lay in the fact that the threshold is almost always a round number. It could be justified to be discretionary (without being arbitrary), with respect to the acknowledgement of it.

Within this background of continuous risk curve leading to discontinuous decisions the point is: does the "one threshold two category" pattern the best tool? We shall advocate for "two threshold, three category" (TTTC) both for medical guidelines (the case of cancer prone women) and for public policy (accreditation according to the activity level).

ARTICLE
Recommendations or guidelines aim at an improvement of appropriateness between diseases and treatments or more generally between conditions and interventions. Intervention choices are almost dichotomous choices: to perform or not. A 60% bridge is not a bridge and perform a 80% appendectomy is meaningless.

The nature of disease (1), qualitative or quantitative is an old, but still existing, debate. If some "diseases" are quantitatively define like diabetes, some others are more qualitative (Measles, Huntington disease for exempla). But whatever if a disease is quantitative or a qualitative state, risk is, at least through its measurement, substantively a quantitative concept (2-5). Therefore guidelines for risk management face the problem of how to manage to find appropriateness between on one hand a dichotomous choice and on the other a continuous risk curve.
Since which risk level should we treat dyslipidemia or hypertension, should we offer screening for breast cancer, for colorectal cancer with either FOBT or colonoscopy? Since which level of activity (a surrogate for experience itself a surrogate for quality) should we allow to operate a cardiac surgery center or a maternity.
It could be seen as quite strange that a person with a Diastolic Arterial Pressure of 96 mm Hg require a treatment while another with 94 mm Hg and a risk extremely close to the first one, will not be under treatment. For Hypertension it is even worst since a high variability of the variable at stake is observed (6). Mammography screening advocates argue that a women 50 years and 1 day old was the same two days earlier. And a cardiac surgeon who perform 201 interventions a year should be seen as a "safe one" while the one with 199 interventions ought to be ban. What it is probably reliable for a difference like 300 vs. 30 interventions a year, deserves less confidence when the gap is of two interventions i.e. 1/100 (the arbitrary value chosen for define that is "futile" (7)). Therefore something that is seen as futile is in the same time absolutely relevant. On the other hand it could not be argue step by step that 1 is quite the same than 1000: How many grain of wheat do we need to obtain a pile?

The paradigm of this problem is that one of the slippery slope (soft slope in France with an emphasis on the cause while US terminology is on the expected consequence). One can come from an evidence-based decision in favor of an intervention and go unto an evidence-based decision against without knowing when he leaves one zone for an another. In France prenatal diagnosis (and abortion) is, on the basis of the law, proposed for disease of a particular gravity. It could be imagine an almost continuous example starting from anencephalia unto a statistical expected lower IQ. Furthermore a disease being culturally define, that is true, hinc et nunc will be false elsewhere and/or latter.

Guidelines makers however have to take decision; indeed no decision is a decision. Guidelines are needed to avoid the development of variable medical practices i.e. two person in the same condition being offered different treatment. Discretionary threshold (unfit) is assumed to be better than heterogeneity (inequity). The determination of the threshold is discretionary but not arbitrary meaning that expert choose a breaking point on the curve within a range of plausible value define by efficacy analyze, risk-benefit analyze, cost-benefit analyze....

The clue for the discretionary nature of the choice lay in the round number attractiveness that entails the threshold to be almost a round number. For example tachycardia was long ago define for heart rate above 100/mm until analysis shows a lack of sensitivity for pathologic conditions, currently a rate of 90 should be used (8), but it takes time to overcome dogma and the "round number rule".

It could be justified to be discretionary, without being arbitrary, with respect to the acknowledgement of it. Within this background of continuous risk curve leading to discontinuous decisions the point is: does the "one threshold two category" pattern the best tool? We shall advocate for "two threshold, three category" (TTTC)

Indeed, the three categories define with two threshold should be seen as something creating a space of complementary analyze where to offer additional parameters for decision making. The strongest parameter (or a set of) is (are) used in the first step (setting the thresholds) and more parameters may be used within, the "in between" category. For example some local hospitals are seen as less safe or underequipped or experience lacking. For significant differences, mandatory intervention (ban) may be justified, however for small (if any perceptible) difference others parameters (distance or time delay to reach a reference hospital, trends in the population and activity...) may be taking in account for the decision.

The single threshold is often use in institutional or consensus position. May be, the assignment and the commitment of the task force for a position induce a strong output like a dichotomous position whereas a softer position may be seen as a sign of weakness or of indecisiveness. For example fluoride supplementation is limited (but required) to children 3 years of age and older in areas where there is less than 0.3 ppm of fluoride in the water
supply (9). The diet or insulin therapy is offered only to pregnant women with a fasting plasma glucose level above or equal to 105 mg/dL or a 2-hour post-glucose load value above or equal 200 mg/dL (10). The CDC choose in 94 the level of 10 mg/dL as the threshold level for lead poisoning prevention, however in the same article it is underline that "Lead is toxic wherever it is found".

On the other hand, example of proposition of two thresholds exists in many field such as public risk management for ecological risk. Suter et al (11) advocate classifying risk as insignificant, significant or intermediate. In medicine, McNeil (12) tackling the problem of node negative early breast cancer and the utilization of adjuvant chemotherapy, state that the indication relies on the risk of recurrence. Prognostic factors had been described and validated, it could be said that for tumors less than 1 cm the decision is often no and for those over 2cm it is often yes. For those in between he underlines that "it depend currently on subjective factors such as an individual's tolerance to risk as well as objective data available". The American Heart Association for the prevention of bacterial endocarditis stratified the risk according to three categories: high, moderate and negligible (13). And for hypertension some authors explicitly use a TTTC approach for hypertension for example: The treatment is initiated for diastolic blood pressure between 90 and 100 and a systolic blood pressure between 140 and 160. Others risk factors (dyslipidemia, tabagism...) make the therapeutic threshold to be the lowest value (14). Lastly some authors feeling uncomfortable with the single threshold approach, without taking a formal TTTC frame use implicitly a concept of fuzzy threshold like the Canadian Hypertension Society in its 97' report (15): "Non pharmacological management should be considered for pregnant women with a systolic blood pressure of 140-150 mm Hg or a diastolic pressure of 90-99 mm Hg, or both". The meaning is not to offer that intervention in between 140 and 150 or/and 90 and 99 but starting from that "value" that in fact is a range.

The TTTC approach had been formalized (16) for diagnostic test with two threshold but even four categories: assumed to be almost certainly normal, not assumed to be almost certainly normal, not assumed to be almost certainly abnormal, assumed to be almost certainly abnormal. The two extreme category refer as strong and the two medium as weak. Others example may be taken also for clinical diagnosis with three situations: probable versus possible versus unlikely (17). We used that approach in order to organize the Recommendations for Medical Management of Hereditary Breast and Ovarian Cancer (18). For example we propose that a women should be tested if her a priori probability of harboring a mutation is greater or equal than 25% and should not be tested if her a priori risk is below 5% while the American Society of Clinical Oncology recommendation is for women with a risk above 10% (19).

One of the risk of one threshold two categories pattern is that according to corporate tyranny (20) induce by the authority value of an institutional collective position, unfair decision may be taken. The "best" decision is the one that is both scientifically valid (the risk level) and democratically discuss and accepted. Policy and casuistic should not be rule out, and when residual doubt is not negligible canvass may be better than automatic blinded decision. On the other hand situation where confidence about the relationship between risk level and the output is high, do not deserve a specific analyze, it will be the negation of the generalization of knowledge and a waste of time, energy and of expedient.

Using a TTTC approach allow to solve the recurrent question of "I'm not like anybody else", "my town is not like any others" by setting two limits above and below which it can be said that specificity are of no value according to the situation at stake but within that two level discussion should be open and particularism in contrast have to be take in account.
The two thresholds, three categories seem to be a useful frame for decision making when no clear-cut threshold exists.

REFERENCES
A PUBLIC HEALTH BASIS FOR FOOD SAFETY OBJECTIVES

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ABSTRACT
Food Safety Objectives (FSOs) are emerging as important tools for management of microbial and chemical hazards in food. The Codex Alimentarius Commission for Food Hygiene has defined FSOs as “a statement based on a risk analysis process, which expresses the level of a hazard in a food that is tolerable in relation to an appropriate level of protection”. Hence, defining FSOs explicitly requires definition of the desired level of protection (acceptable risk). There is currently not a generally accepted metric for defining acceptable risk in the context of food hygiene. We propose the use of an integrated measure of public health, the Disability Adjusted Life Year (DALY) as a means of expressing risk (i.e. a function of the probability and severity of undesirable health effects) by different agents, leading to different disease end-points. We illustrate this approach by evaluating the public health impact of exposure to genotoxic carcinogens under the current regulatory regimes, and derive an equivalent level of acceptable risk for infectious gastro-intestinal pathogenic bacteria.

INTRODUCTION
Food Safety Objectives (FSOs) have been introduced by international bodies such as the Codex Alimentarius Commission on Food Hygiene (CCFH) and the International Commission on the Microbiological Specifications of Foods (ICMSF). An FSO is defined by CCFH (Anonymous, 1998; Jouve, 1998 has suggested the italicised additions) as “a statement based on a risk analysis process, which expresses the level or concentration of a hazard in a food and/or its maximum frequency that is tolerable in relation to an appropriate level of protection”. FSOs differ from traditional microbiological criteria because they should explicitly be based on a risk analysis process and “translate the required level of protection into a set of quantitative requirements that enable appropriate design, realisation and examination of products/processes/control measures (Jouve, 1998)”. In contrast, microbiological criteria (e.g. ICMSF, 1986) are derived from the characteristics of a well-controlled production process. Limits for chemicals in food are usually derived from a risk assessment process, and as such conform to the definition of an FSO. Risk analysis is defined by CCFH as consisting of three different, but mutually interrelated stages: risk assessment, risk management and risk communication. FSOs are considered by ICMSF (Van Schothorst, 1998) as essential components of this process by “linking information from the risk assessment and risk management processes with the establishment of effective measures to control the identified risk(s)”. This principle is illustrated in Figure 1. The ultimate goal of food safety standards is to protect public health and to promote equivalence in international trade. A target for the acceptable level of risk (also positively phrased the appropriate level of consumer protection) can be defined in a disease or agent specific manner, or in an integrated form, as will be discussed below. To use a defined level of acceptable risk as the basis of standard setting, explicit quantitative information on the relation between food quality and population health is necessary. This is the domain of
Quantitative Risk Assessment (QRA). The risk estimate is then considered in the risk management process. If the risk is considered unacceptable, the process needs to be modified until the desired level of protection is met. Then, the results of the QRA serve as inputs to HACCP plans. The FSO can be deduced from the QRA results by extracting information on the level of the hazard in the food under the criterion of acceptable risk (Fig. 2).

![Diagram of Food Safety Objectives (FSOs) bridging the gap between product quality and public health](image)

*Figure 1. Food Safety Objectives bridging the gap between product quality and public health*

Note that it is theoretically possible that FSOs define an acceptable concentration that is far below the limit of detection of current analytical methods (e.g. mean concentration of pathogen X in product Y less than 1 per 1000 kg). In such cases, direct verification is not possible. Note also that one common contamination level of food may lead to a different level of protection in different populations, and that different FSOs may lead to the same level of protection. This implies that FSOs are only suited for equivalence discussions with proper reference to the target population.

Control measures are installed to meet an FSO in a stepwise fashion. First, performance criteria are defined, which define the required outcome of a control measure at a step or combination of steps in the production process. Then, process criteria are defined that ensure consistently meeting the performance criteria. These process criteria are the subject of direct monitoring and control in the day to day running of a food production process (Van Schothorst, 1998).
DEFINING ACCEPTABLE RISK FROM A PUBLIC HEALTH PERSPECTIVE

Foodborne pathogens may cause a great diversity of illnesses, with widely different impact on public health. Even one agent is usually related to different illnesses, possibly in different populations. The health impact may vary from mild gastrointestinal disturbances to life-long sequelae and even death. A public health based standard for acceptable risk from microorganisms in food should therefore not only be based on the probability of disease but also on its severity. This calls for a non-specific approach to measuring the health burden of foodborne illness. Health-related Quality of Life scales (Quality or Disability Adjusted Life Years, QALYs or DALYs) are commonly used for this purpose in health economics and medical decision making, and are increasingly being used in the domain of public health. The basis of these scales is the concept of loss of (healthy) life years, comprising and integrating the effects of mortality and morbidity. Mortality is accounted for by the number of life years lost (LYL), defined as the difference between the actual age at death, and the life expectancy at that age. Morbidity is considered to reduce the value of life during the period of disease and possibly chronic sequelae. A severity weight, expressed as a factor between 0 and 1, accounts for the different levels of impact that specific diseases may have on individual or population health. Thus, the loss of health life years due to morbidity (YLD – years lived with disability) is expressed as the time lived with disease, multiplied by the matching severity weight. The loss of DALYs in a population is then computed by summation of LYL and YLD.

We have previously used the DALY scale to balance the risks related to drinking water disinfection (Havelaar et al., submitted). In this case study, the positive health effects of disinfection with ozone (reduction of the risk of infection with the protozoan Cryptosporidium parvum) significantly outweighed the negative effects related to the production of carcinogenic bromate. We now attempt to extend this approach to derive a target value for acceptable risk from pathogens in food that offers a similar level of protection as current standards for genotoxic carcinogenic compounds.

Consider the commonly used definition of acceptable risk of genotoxic carcinogens: “less than one excess cancer case after lifetime exposure”. If a cohort of 1 million people would experience this risk, there would be 1 excess cancer case in this cohort. As an example, we

\[\text{Note that dose-response models for both types of agents are based on the single-hit assumption. For other agents, fulfilling a threshold type of response, the need to compare health effects is less urgent because a "no-effect" level can be defined.}\]
consider renal cell cancer (RCC), related e.g. to exposure to bromate$^2$. RCC occurs at a median age of 65 years (standardised life expectancy 19 years) and has a case-fatality ratio of 60%. Thus, ignoring the relatively minor effects of morbidity, the health burden of one case of RCC is equal to the number of Life Years Lost, which is $1 \times 60\% \times 19 = 11.4$ years (Havelaar et al., submitted). Averaged over the total life expectancy of this population at birth (80 years), the annual (acceptable) loss of healthy life years is a fraction of $11.4/80 \times 10^6 = 1.4 \times 10^{-7}$.$^3$

Now, consider the health effects of exposure to pathogenic micro-organisms. Havelaar et al. (1999) have recently completed a survey of the health burden of infection with thermophilic Campylobacter spp. in the Dutch population. Three types of disease were considered: gastroenteritis (GE, in the general population and leading to visit of a general practitioner), Guillain-Barré syndrome (GBS, clinical phase as well as residual symptoms) and reactive arthritis. Table 1 shows a summary of results, indicating an annual loss of approximately 1500 DALYs per year in the Dutch population of 15 million. This is a fraction of $10^{-4}$, or more than 700 times higher than deemed acceptable for genotoxic carcinogens.

Table 1. Health burden of infection with thermophilic Campylobacter spp. in the Netherlands

<table>
<thead>
<tr>
<th>Disease Type</th>
<th>Incidence</th>
<th>YLD</th>
<th>Mortality</th>
<th>LYL</th>
<th>DALY</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE population</td>
<td>300000</td>
<td>300</td>
<td></td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>GE general practitioner</td>
<td>20000</td>
<td>200</td>
<td>30</td>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>GBS clinical</td>
<td>60</td>
<td>10</td>
<td>1</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>GBS residual</td>
<td>60</td>
<td>400</td>
<td></td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>Reactive arthritis</td>
<td>6000</td>
<td>200</td>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Total</td>
<td>1110</td>
<td>430</td>
<td>1540</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All values rounded off to one significant digit

DISCUSSION

The concept of FSOs has emerged primarily in the context of microbiological hazards. In contrast to chemical hazards, there is no generally accepted basis for defining acceptable risk of pathogens. This was mainly related to the absence of quantitative information on the relation between exposure to pathogens in food and consequent health risks. Recent advances in risk assessment methodology, notably in dose-response modelling, have created a breakthrough, even when taking the limitations of the current models into account. Now, the attention shifts to the definition of acceptable risk for foodborne pathogens. CCFH states that “the tolerable level of risk should be determined primarily by human health considerations. Depending on the context, other factors could be taken into account, such as economic costs, benefits, technical feasibility and societal preferences”. We propose health related quality of life measures, such as the DALY, to quantify the public health dimension of risk in a

$^2$ Note that bromate is not only carcinogenic to the kidney, but also to the thyroid and mesothelia. Conventionally, only one end-point is considered when deriving limit values; but multiple end-points can easily be integrated into a quality of life approach.

$^3$ Note that cancer types other than RCC may occur at different ages, and may have different prognoses. Hence, the level of protection of one standard for acceptable risk from all types of cancer does not lead to a common level of protection.
structured, comprehensive and transparent manner. It is a highly flexible concept, which can be used for simple comparisons of risks by different agents, as described in this paper, but also in more complex models that emphasise specific aspects of societal values (see e.g. Williams, 1996).

Foodborne risks often evoke strong emotional reactions in the public and policy makers have to take these into account when deciding about acceptability of contaminants in food. Many dimensions, other than health play a key role in these decisions, even if the emotions are fed by a perceived health risk. Against this background, the use of health-related quality of life measures could be considered inappropriate because they do not adequately capture the public’s values. In reality, both perceived and actual risks will contribute to the decision making process and a public health basis for defining acceptable risk is necessary.

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RISK MANAGEMENT STRATEGIES IN RELATION TO FOOD SAFETY: WHO BENEFITS AND WHO PAYS?

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ABSTRACT
Food safety is an issue of increasing importance. Safe food starts with safe ‘ground material’, i.e., healthy animals. Incentives for the producers (farmers, slaughter plants) to apply risk management strategies are diverse. In absence of a perfect (transparent) market, consumer behaviour is not enough. Additional incentives can be provided via laws or regulations that force the agricultural sector to develop and apply risk reduction programs. Dutch case studies on Salmonella in poultry and paratuberculosis in dairy cattle show that the distribution of costs and benefits from such programs may influence the motivation of farmers to join. More insight into this aspect may help to develop more efficient programs.

INTRODUCTION
Efforts to apply risk management strategies and increase food safety are usually motivated by pointing out the enormous costs that are involved with food-borne diseases. Buzby et al. (1996) report that microbial pathogens in food cause an estimated 6.3-33 million cases of human illness and up to 9,000 deaths in the United States each year. These authors estimated that the four most common bacterial pathogens, Salmonella, Campylobacter jejuni, Escheria coli O157:H7, and Listeria monocytogenes, account for $1.1-$4.1 billion in human illness costs in the United States each year. The authors used the so-called Cost-Of-Illness (COI) method, which measures the sum of medical expenses, forgone earnings of affected individuals, and productivity losses to employers of affected individuals on paid sick leave. Benefits of risk management leading to increased food safety are often estimated as a reduction of the COI. For example, USDA’s Economic Research Service (ESR) estimates the twenty-year public health benefits of a 90% reduction in illness and death from the above mentioned four pathogens to be $7.13-$26.59 billion. Some authors, for example Roberts (1991) argue that COI is the lower-bound estimate of the benefits, because consumers would be willing to pay to reduce the risk of food-borne illness, even if they don’t actually become ill. COI benefit calculations usually only incorporate the reduction of human cases of illness and death. Which is fairly correct, because the damage of pathogens such as Salmonella and Campylobacter on the health of the animals that are the source of the meat products, is almost negligible. Therefore, reduction of animal health costs is almost never an incentive for farmers to invest in risk management strategies related to these pathogens.

In this paper we will address the issue of the distribution of benefits and costs on the farm level, in order to obtain more insight into what incentives are currently expected to motivate farmers to apply certain risk management strategies. We will first give a general overview of possible incentives and then discuss two case studies that were recently carried out in the Netherlands.

INCENTIVES TO APPLY RISK MANAGEMENT STRATEGIES
Consumer behaviour is perhaps the most logical incentive to apply risk management strategies. Generally speaking, consumers could respond to food hazards in four ways
(Weaver, 1995): 1) product avoidance, 2) brand switching, 3) averting, and 4) mitigating actions. Product avoidance and brand switching may directly influence the market price and market share of a specific product and therefore be a strong incentive. Averting actions such as cleaning or cooking the product and mitigating actions such as treatment of illness are not direct economic incentives to the producers of the specific product.

One might argue that in a perfect market, consumer behaviour could be the only incentive necessary to increase food safety to a level desired by the consumers. Only a small group of consumers would buy the ‘unsafe’ products, resulting in a low price and small market share for these products. Most consumers are risk averse and only interested in the ‘safe’ products. The higher demand would then result in a higher price for these safe products, which will cover the extra costs made by the producers to produce the higher safety level (costs of risk management). But, as argued by Unnevehr (1996) and many other authors, this perfect market seems to be non-existing, due to the lack (or the cost) of information about food safety available to the consumer.

Other, and perhaps more important incentives for application of risk management, are laws and regulations. The high number of cases and the high societal costs involved might be the reason that in many countries the government takes the responsibility for food safety. The food safety regulation applied can either be process based or performance based. Performance based regulation might be viewed as the more ‘liberal’ form of regulation, because it sets a certain standard, for example a maximum number of pathogens to be found in a certain product, and leaves it to the producers how to adhere to that standard. However, this type of regulation might be infeasible because of very high information costs. An example of process based regulation can be found in the US, where, since 1996, meat and poultry plants are required to develop Hazard Analysis and Critical Control Point (HACCP) plans, subject to state (FSIS) approval and verification.

CASE STUDY: SALMONELLA IN POULTRY MEAT

Within the Netherlands, Salmonella-infection, is one of the most important foodborne infections, with an estimated number of 100,000 cases per year (De Wit et al., 1996). In about 75% of the cases, poultry are thought to be the source of the infection. This caused the Dutch government require the poultry industry to develop a program that will reduce the percentage of Salmonella-infected flocks (batches) at the slaughter plants, to a maximum of 10%. In 1996, about between 50 and 75% of the flocks at the slaughterhouses were found to be infected with Salmonella.

Since May 1997, the Dutch poultry sector applies a Salmonella-reduction program including measures such as feeding of Salmonella-free feed, hygienic measures (cleansing and disinfecting), treating or eradicating infected flocks, and logistic measures (separation of infected and not infected flocks or batches, i.e., in the hatcheries). Also an extensive monitoring system was started in 1997, including entrance and exit checks for all parts of the production chain. It is not expected that Salmonella reduction will lead to a significantly higher market price for the Dutch poultry products. The Netherlands produces for the international market, and thus has to compete with countries such as Sweden, which claims to be free of Salmonella. The Incentive to reduce Salmonella prevalence thus comes from legislation, and, perhaps in the longer term, the fear of losing export markets or market shares.
The yearly costs of the *Salmonella*-program depend on the efficacy of the measures, i.e., higher efficacy results in less flocks to be treated or eradicated. Therefore the economic calculations were based on the *Salmonella*-transmission model developed by Nauta et al. (1998). Table 1 shows the costs of the program (including monitoring) for each part of the production chain. The table shows that the total costs for *Salmonella* monitoring and control are not evenly distributed among the various parts of the production chain (1998 estimates).

Table 1. Cost of *Salmonella*-monitoring program and *Salmonella*-reduction program in the Netherlands, based on 1998 statistics, in US dollars.

<table>
<thead>
<tr>
<th>Part of the chain</th>
<th>Costs monitoring</th>
<th>Costs reduction</th>
<th>Total costs</th>
<th>Cost per operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding companies</td>
<td>75,000</td>
<td>138,000</td>
<td>213,000</td>
<td>35,500</td>
</tr>
<tr>
<td>Rearing farms</td>
<td>165,000</td>
<td>320,000</td>
<td>485,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Parent stock farms</td>
<td>75,000</td>
<td>1,125,000</td>
<td>1,200,000</td>
<td>2,500</td>
</tr>
<tr>
<td>Hatcheries</td>
<td>440,000</td>
<td>2,193,000</td>
<td>2,633,000</td>
<td>105,000</td>
</tr>
<tr>
<td>Broiler farms</td>
<td>860,000</td>
<td>650,000</td>
<td>1,510,000</td>
<td>1,200</td>
</tr>
<tr>
<td>Slaughterhouses</td>
<td>1,480,000</td>
<td>2,000,000</td>
<td>3,480,000</td>
<td>158,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,095,000</strong></td>
<td><strong>6,426,000</strong></td>
<td><strong>9,521,000</strong></td>
<td></td>
</tr>
</tbody>
</table>

For better insight, the table also provides the costs per operation, i.e., per farm, hatchery, slaughterhouse, etc. We then see that the breeding companies, the hatcheries and the slaughterhouses have the highest costs. But does this mean that these operations ‘suffer’ more from the program than the other parts of the production chain? That’s a difficult question to answer. Fact is that Dutch broiler farms and multiplier farms are usually single-handed or family operated whereas most slaughterhouses, hatcheries and breeding farms in the Netherlands are much bigger. A calculation of the cost per labour equivalent might therefore change the picture. Other insight-enhancing calculations might be the calculation of the relative impact of the measures on the net profit, per animal or per operation. Research is underway to do so.

However, perhaps more important than knowing where the costs are made is knowing where they are paid. Table 1 shows that the program includes costs for the hatcheries of 2,633,000 US dollars. Per egg hatched this is a cost of about 0.5 dollar cent (500 million eggs per year). But hatcheries increased the price of their products (one-day old chickens) by 0.75 to 1.0 dollar cent. The costs for the program are thus transferred to the next part of the production chain, the broiler farms. Broiler farmers have a much weaker position than the hatcheries; they are smaller, with a higher number, and less well organised. In consequence it is difficult for them to transfer their costs to the next part of the chain, the slaughterhouses. A growing percentage (currently 10-15%) of the broiler farmers produce within cooperatives. In many cases the cooperative consists of a combination of a feed company and a slaughter company, it sometimes also includes a hatchery. The cooperative often owns the chickens and pays the farmer for his labour. Within such a structure costs for health care programs can be reshuffled. In May 1999 monitoring results showed that the *Salmonella*-program had reduced the prevalence at the slaughterhouse to 36%, which was still far more than the targeted 10% to be reached in 2000. Many of the measures included in the program will only be successful if farmers are highly motivated (especially the hygiene measures). Part of the lower than expected efficacy of the program is thought to come from incomplete co-operation of the farmers. This might be explained by lack of motivation due to unease about the distribution (and height) of the costs. But it is also thought that the measures at such are not able to reduce...
the prevalence enough. Therefore, a stricter program will be applied in the near future, including logistic measures at the slaughterhouse, i.e., separate slaughter of affected and unaffected flocks. It is yet to be seen who will bear the costs of this highly expensive measure. One might argue that if the slaughter plants transfer these costs to the preceding parts of the chain (in effect: lower meat prices), this will reduce the motivation to adhere to the reduction program.

**CASE STUDY: PARATUBERCULOSIS (JOHNE'S DISEASE) IN DAIRY CATTLE**

Paratuberculosis or Johne’s disease has been implicated as a possible cause, or complicating infection, in people with Crohn’s disease. There is evidence both for and against this theory, reviewed by, amongst others, Chiodini (1989) and Thompson (1994). Humans can become contaminated with the pathogen causing paratuberculosis (*mycobacterium bovis*) due to the consumption of raw milk or meat from infectious animals (animals shedding the bacterium). The zoonotic potential of paratuberculosis is not proven and simple treatment (pasteurisation, cooking, etc.) is enough to kill the bacterium. Still, the Dutch veterinary services and farmers organisations fear loss of consumers’ trust in cattle products when consumers become aware of the fact that many Dutch farms house a (usually very low) number of cattle with paratuberculosis. This fear for consumer distrust, and thus potential price falls and loss of marketshares, was the main motive to study the possibilities for a compulsory eradication program. A submotive was the fact that clinical and subclinical forms of paratuberculosis lead to losses for the farmers because of diarrhoea, decreased milk production, weight loss and premature disposal of the animals.

To provide insight into the epidemiological and economic impact of various eradication strategies, we developed a Monte Carlo simulation model. The model mimics the spread of paratuberculosis on the farm and sector level in situations with and without application of a certain eradication/prevention strategy. Strategies included combinations of testing (testing with ELISA or faecal test, culling the positive animals) and management measures. Cows can only become infected with paratuberculosis at a young age (up to 1 year), so management measures were focussed on reducing the contacts between older cows (potential shedders of the pathogen) and calves by measures such as: improved hygiene, feeding of milk replacer, and separate housing of young stock. The results showed clearly that testing alone (including culling the positive animals) is not sufficient to reduce the prevalence of paratuberculosis. The main reason for this is that the tests are almost unable to detect the latently infected animals and that they also miss 40 to 80% of the clinical and subclinical animals. Only strategies including severe management measures, such as separate housing of the calves, succeed in reducing the prevalence. For the economic evaluation only the benefits resulting from a reduction in the losses due to paratuberculosis were incorporated, hence possible consumers’ distrust (lower milk and meat prices) was not included. It was not expected that paratuberculosis or freedom from paratuberculosis would influence milk or meat prices. The results showed that for about 5 to 10% of the farms (the larger and highly infected farms) eradication was attractive. But for the average Dutch farm (including both infected and non-infected farms) the benefit cost ratio’s were between 0.2 and 0.72, on a planning horizon of 20 years. This indicates that none of the proposed eradication programs was economically attractive, at least not for the ‘average dairy farm’, which is mainly caused by the high costs of separate housing of the calves.

The results were discussed with farmers’ representatives and it was concluded that the unfavourable benefit cost ratio’s would make it impossible to motivate farmers to accept an eradication program forced upon them by their ‘own’ organisations (veterinary services,
Dutch farmers organisation). The potential thread of failing consumer demands was not thought to be large enough to overcome the low benefit cost ratio's. Also on governmental level (Dutch government or European Union) no actions were expected. Therefore, it was decided to stop the development of a compulsory eradication program. Instead, the veterinary services and the Dutch farmers organisation are currently developing a voluntary program, joint by an extensive information and promotion campaign.

CONCLUSION AND DISCUSSION
Food safety is an issue of increasing importance. Providing safe food starts with safe ‘ground material’. This means that one can expect that in future farmers will be confronted more and more with requests to implement risk management strategies. Currently many researchers focus on the technical side of this issue, i.e., what are effective strategies. We argue that more attention should be given to the presence or non-presence of incentives, i.e., to the motivation of the farmers to apply the strategies or adhere to the rules. As in most programs the success is very much dependent on factors that are difficult to monitor, such as discipline with hygiene measures, programs will never be successful if the participants are not motivated. Often, motivation will be linked closely with the distribution of the costs and benefits of the strategies. In most cases, risk management programs will be applied in order to comply with laws or regulations or in order to avoid price falls or loss of market shares. Profits such as higher prices or market shares are often not expected to occur. This means that costs of the programs will directly influence the net profits of the farmers. A better insight into this matter might help to understand why certain food risks are difficult to reduce and might also help in the development of more successful programs.

REFERENCES
IMPLEMENTATION OF THE PUBLIC SAFETY POLICY IN RIJNMOND AREA

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ABSTRACT
Rotterdam harbour, being the largest in the world, presents a vast agglomeration of chemical and petrochemical industries. Because of the big concentration of industrial activities and its location close to populated areas, there is a need in an active safety policy. The basis of this policy is a systematic management of industrial risk using quantified risk analysis and quantified risk criteria. According to Dutch legislation, industries, which use large quantities of hazardous materials, are obliged to submit a public safety report. This year important developments are expected to the safety policy in Netherlands, related to the national implementation of the Seveso II Directive. Under this law the efforts of three different authorities, controlling the public safety, occupational safety and the fire safety, are united to assure a more integral approach to the safety problems and more attention to the aspects of safety management.

1. INTRODUCTION
Rijnmond (the mouth of the river Rhine) is a delta area with the world's largest sea-port, the port of Rotterdam. It is also the most densely populated and industrialised area in the Netherlands. In total 1.2 million people are living within an area that seize roughly 800 km²; this corresponds with 8% of the Dutch population on 2% of the territory. More than 18,000 companies are located here and about 15% of the gross national product is gained in Rijnmond. Most of the industry is situated along the south bank of the 'Nieuwe Waterweg', a 40-km stretch of river that basically forms the mouth of the river Rhine.

The industrial expansion of the 1950s and 1960s has lead to the severe air pollution in the area. Because of that an Environmental Protection Agency Rijnmond (DCMR) was set up. Although the air quality has improved since then, there is still a heavy burden on the environment. DCMR carries out environmental tasks and activities in the field of policy preparation, advice, control and research with the aim to achieve and maintain a high standard of the environmental quality in the Rijnmond area. DCMR works on different administrative levels: it manages the environmental affairs of Rotterdam, 17 smaller neighbouring municipalities, and part of the province of South Holland.

2. DUTCH PUBLIC SAFETY POLICY
The storage, transport, production and processing of hazardous materials are activities that can constitute a danger to the safety of population. Because of the location of the industries in Rijnmond close to the living areas, there is a need for an active safety policy. The safety policy has been developed over the years in the Netherlands, it is aimed at preventing incidents and at limiting the consequences as much as possible should such incidents occur. The basis of this policy is a systematic management of industrial risk using quantified risk analysis and quantified risk criteria.
To decide if a certain activity can be regarded as acceptable, the calculated risks are compared to the national norms. The first norm is the individual risk: the probability per year that a person, present unprotected at a certain location at the time of the accident, will die because of this accident. The places with the similar individual risk can be connected, giving the individual risk contours. The existing norm for the individual risk is $10^{-6}$ (probability of one in a million per year). According to Dutch safety policy no sensitive objects (living houses, hospitals, schools, etc) can be located within the $10^{-6}$ contour. This norm works two ways: no plants may be built near residential areas which cause there a higher risk than $10^{-6}$, but also no new houses may be built in an area where the individual risk of nearby industries is higher than $10^{-6}$.

The second norm for the public safety is the societal (group) risk: the relationship between the number of people killed in a single accident and the chance that this number will be exceeded. The existing norm for the group risk is a chance of $10^{-5}$ per year of an accident with maximum 10 deaths, a chance of $10^{-7}$ per year of an accident with maximum 100 deaths, etc. This implies a heavier weight for the accidents with the large consequences. Similar norms have also been developed for the transportation of hazardous materials.

Different from many other countries, risk analysis became in the Netherlands the main instrument for making decisions, dealing with the acceptability of potentially hazardous activities and the location of industries and living areas. The development of standardised procedures and software made it possible to compare risks to the national risk norms and to each other. According to Dutch implementation of the Seveso Directive, industries using large quantities of hazardous materials are obliged to submit a public safety report (EVR) containing a risk analysis of the installations. This constitutes a part of the license application procedure. The contents of the report is used to judge whether the activity is acceptable and whether or not the ALARA principle has been used sufficiently or the further measures are necessary.

3. OVERVIEW OF THE INDUSTRIAL ACTIVITIES IN THE AREA

One of the features of the Rijnmond area is the interrelated nature of the port and industrial areas, infrastructure and the residential environment. Some of the residential areas are lying less than 100 meters away from the industry. The most striking examples of that are two villages, Pernis and Rozenburg, completely embedded in the industrial area.

The industrial complex of Rijnmond (5 refineries and more than 75 chemical industries and tank storage and transshipment companies) is divided into four main areas (fig. 1). The closest to the city of Rotterdam is the Pernis area, which has got its name from the village lying here. Shell was one of the first major industries to settle in Pernis in the thirties. This area consists mainly of petrochemical companies. Secondly there is the Botlek area, situated somewhat more to the west. In addition to petrochemical companies such as Lyondell and Huntsman, manufacturers of anorganic chemicals and bulk liquid (mainly chemicals), storage companies can also be found here. Further to the west is the Europoort area. Industrial activities started here in the sixties. Refineries, bulk liquid storage of crude and derivatives and some chemical plants are located here. The most western section of the industrial complex is the Maasvlakte, an artificial land area, result of the land reclamation; parts of it are still under development. Container terminals, storage facilities for crude oil and a large power plant are located here. It is expected that the further development of Rotterdam harbour will lead to lack of space in the
area. At the moment an investigation is taking place of further land reclamation, which could lead to the appearance of Maasvlakte II.

Figure 1: The Rijnmond area

Many chemical companies in the area are producing the semi-finished products, which are further used for production of plastics and resins. Some of these companies produce plastic and resins themselves. Companies, specialised in industrial gases, such as Air Products en Air Liquide, are producing hydrogen, oxygen or nitrogen. Many of these are used in processes within the area, for example, the vinyl chloride, produced at Akzo, is used in Shell Chemical's PVC factory. Another part of the chemical industry in the Rijnmond area concentrates on the manufacturing of chemicals for agriculture and animal husbandry such as fertilisers and pesticides. Usually these are separate companies, but at some of them, for example Akzo, the production of heavy chemicals for plastics (chlorine) and pesticides are combined. Finally, there are companies that specialise in the production of anorganic chemicals, such as Kemira Pigments, where titanium dioxide is produced.

Most of the raw materials and products from the chemical industry and refineries are liquids. They are stored in tanks and can be loaded to ships, tankers and occasionally railway wagons. Raw materials and products are also often transported by pipeline. Most of chemical companies and some of the refineries have limited storage capacity; if more storage capacity
is needed, they call in companies, specialised in the storage and transshipment. In Rijnmond area there are 19 locations for the storage and transshipment of oil products and chemicals, with a total throughput of approximately 135 million ton per year.

In total there are about 50 companies in the area, which are obliged to produce the public safety report, containing the risk analysis of the installations. The summation of the $10^{-6}$ and $10^{-8}$ individual risk contours from these companies, presented by the province of South-Holland in its 'Sector document', is given in the fig. 1. It can be seen that there are no sensitive objects lying within the $10^{-6}$ contour. This is ensured by the existing public safety policy.

4. IMPLEMENTATION OF SEVESO II IN THE NETHERLANDS

According to Dutch implementation of the 1982 Seveso Directive, companies, presenting high risk to population (because of holding more than specified quantities of toxic or flammable substances), were obliged to submit two reports to the authorities: a public safety report and an occupational safety report. In connection with other legislation, there was an additional reporting obligation to submit a company fire brigade report. These reports were evaluated separately by three different regulatory bodies.

This year the BRZO'99 (Dutch acronym of Risks of Major Accidents Decree), the implementation of the Seveso II Directive in the Netherlands, is put into force.

In the BRZO'99 the distinction is made between top-tier and lower-tier sites. For the top-tier companies the most important change is integration of the above mentioned reporting obligations into one report: the safety report. Evaluating a safety report will thus be a joint activity between the three regulatory bodies involved, as will be the case in carrying out the required inspections at both upper-tier and lower-tier establishments. This has to assure the more integral approach to the safety problems and more attention to the aspects of safety management. In the Rijnmond region these joint activities are an issue of major importance.

There are located about 50 top-tier companies (refineries and petrochemical industries) and about 30 lower-tier companies (small storage facilities and smaller chemical industries) here. As a consequence, organising the required co-operation is a significant task in itself.

Co-operation between three authorities in Rijnmond region started in a number of pilot projects. Parallel with the pilot projects it was considered beneficial to set up a formal organisational structure to supervise the execution of the required activities. At the operational level, a co-ordinating committee was established, under which two kinds of subgroups are operating: working groups and project groups. The working groups function on a temporary basis and address general issues dealing with the implementation of the BRZO'99. The project groups are teams that are involved in evaluating the notification and the safety report, and in carrying out the inspection. Thus, the project groups are concerned with the actual implementation of BRZO'99. For each project (= company), a project group is installed representing the three regulatory bodies. At the managerial level, a steering committee is established which consists of the directors of the three bodies.
INVESTIGATION OF THE INFLUENCE OF ECONOMIC, FINANCIAL, POLITICAL AND SOCIAL FACTORS ON RISK OF SOCIAL SHOCKS

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ABSTRACT The computer technology is created to analyze dynamics of cost-benefit and work out optimal social policy minimizing risk of social shocks. It is based on mathematical methods of data analysis, theory of optimization, theory of modeling of complex dynamic systems, theory of catastrophes. The tasks of work were: I) determination of sequence and size of measures necessary for support of appropriate level of social security of citizens (SSC); 2) analysis of various scripts of realization of reforms; 3) ranking various measures which are included in these scripts on cost-benefits for separate social groups and SSC of all society in the whole. The main goal function is formulated as follows: to determine dynamics of changes of the economic, financial, social, political characteristics of a society ensuring duly transformation of dividends, obtained from realization of reforms in such social programs, which would allow to brake growth of social intensity, caused by realization of reforms. The realization of this goal function of control of reforms is carried out within the framework of limitations representing such compromises between elite classes, when the interest of each of them is not contradict interests of a society in whole. With the help of the developed computer technology the accounts of dynamics of change of social intensity for a number of countries of East Europe and Ukraine are carried out. The obtained results are used for ranking the mentioned above countries on a degree of risk of investments in their development.

1 THE MODEL OF RISK VALUATION OF SOCIOGENIC CATASTROPHES
At present there is plenty of models, permitting to describe the interconnection between parameters of social-economic systems [1-3]. The excessive detailed elaboration of models (up to hundreds and thousands of equations), causing sharp growth of their dimension, is "a payment" for an aspiration to adapt model for a particular database, which User exploits. There is a problem of selection of such generalized parameters, which would allow to investigate behavior of a system in control area using limited number of parameters. We use UDTC - the butterfly for study of the effect of economic, financial, political and social factors on level of risk of social shocks in a society. Let's consider that the first steady state corresponds to normal financial-economic and social situation in a society. The second state corresponds to instability of a financial and economic situation (social stability is kept). Third one corresponds to financial-economic and social catastrophe. Let's consider representations of Keynes [4] that the economy is reduced to functions of four interconnected markets: the market of the goods and services, market of labor, money market and market of shares and obligations. Let's add to these the market of social guaranties. Then the following considerations concerning determination of parameters describing social, political, financial and economic characteristics of society can be formulated.

1. We shall characterize the market of labor (parameter a) by parameters, that reflect such characteristics of the market of labor as a degree of operation, peculiarities of distribution, degree of market liberalism.
2. The market of the finance and valuable papers (parameter b) will be characterized by parameters, standard in the financial world: 1) by a level of business, 2) by a rate of inflation, 3) by norm of bank percent, 4) by rates of the taxes, 5) by a level of the credits, 6) by a level of the foreign investments.

3. The market of the goods and services (parameter c) will be characterized by parameters, that reflect process of accumulation of the material goods and services: 1) a level of GNI, 2) a level of material resources, 3) a population, 4) a level of pollution, 5) intensity of agricultural manufacture. A material level of living can be estimated with the help of these parameters.

4. The market of social guarantees of services (parameter d) will be characterized by parameters, that reflect the level of a civil liberty in a society: 1) social defense, 2) freedom of press, 3) great number of parties, 4) efficiency of functioning democratic institutes.

2. RANKING SOME EAST EUROPE COUNTRIES ON A DEGREE OF RISK OF INVESTMENTS IN THEIR DEVELOPMENT

With the help of the developed computer technology the account of dynamics of change of social intensity for Hungary (fig. 1), Poland (fig. 2), Ukraine (fig. 3) and Russia (fig. 4) was carried out. The date of macro-economic instability in East Europe Countries [5] was utilized.

On fig.1-4 the projections of surfaces describing the catastrophe on the surface c and d for above countries are shown. The results obtained for Hungary and Poland show, that financial-economic and social situation for these countries is in state 1 (normal financial-economic and social situation in a society). The results obtained for Ukraine and Russia show, that financial-economic and social situation for these countries is in state 2 (to instability of a financial and economic situation).

The results of calculation of risk of transition from state 1 into state 2 and from state 1 into state 3 are shown correspondingly in the Tables 1 and 2, where \( R_i \) and \( S_i \) - (i=a,b,c,d) are, respectively, risks and stability reserves of appropriate markets.
These tables show some deference between Hungary and Poland. There are trajectories of change of its parameters reflecting changes in a society, which transit system at first in the state 2 (economy-financial crisis), and then in the state 3 (combination of all crises). Besides there are trajectories transferring system from the state 1 directly into the state 3 , i.e. simultaneous development of all crises. Such trajectories are connected with changes of parameter c (for Hungary) and d (for Poland). The market of the goods and services demands more attention for Hungary and the market of social guarantees demands more attention for Poland. The Russia has more high total risk level to transform in state 3 then other mentioned countries. Compared with Ukraine it has more instable situation on markets of finance and of
social guarantees. So the mentioned countries may be ranking on a degree of risk of investments in their development as follows: 1) Hungary, 2) Poland, 3) Ukraine, 4) Russia.

3. ANALYSIS OF VARIOUS SCRIPTS OF REALIZATION OF REFORMS TO ECONOMY-FINANCIAL STABILIZATION

If the initial state of system corresponds to state 2 or 3, the trajectories of returning of system in the state 1 (normalization of a social, financial and economic situation) can be determined. Besides the problem of optimum control of parameters [4] can be formulated, that minimizes time of exit from crisis and resources, required for that purpose.

Results presented for Ukraine (fig. 3) and Russia (fig. 4) show there are a number of ways out of crisis. The trajectories 1-5 show various scripts of realization of reforms to economy-financial stabilization, when the system moves from state 2 into the state 1.

The trajectories 1-2 are connected with fast jump from state 2 to state 1, under decrease of parameters c and d. It means, that parameters characterized market of goods and civil liberty begin to increase. This may be occur due to sharp restriction of consumption (trajectory 2). It is so called shock therapy. This script of reforms was realized in Poland by Balzerovich's government [6]. The trajectory 3 is connected with slowly varying of economy-financial system. This is the pathway of Ukraine. At first step it is connected with parameter c decrease, that means the market of goods increases. At second step the civil liberty increase occurs. At third step some restriction on goods and service market leads to more stable state of economy-financial situation.

For Russia the slow (non-shock) script may be realized by the same manner (trajectory 4). The principal difference is that first step come after some civil liberty decrease ("iron hand" government). But excessive decrease of civil liberty (trajectory 4) transforms system in state 3 (combination of all crises).

The more detail calculations were carried out to determine: 1) surfaces share areas of parameters appropriate to various states of economy-financial system; 2) the sequence and size of measures necessary for support of appropriate level of SSC; 3) ranking various measures which are included in these scripts on cost-benefits for separate social groups and SSC of all society in the whole. For these purposes the modification of mathematical model [3] was utilized.

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ABSTRACT
Russian Ministry of Emergencies has accepted the decision on transition of state management technogenous and natural safety on methodology based on risk. Russia the second country after the Netherlands accepting such decision. The reasons and problems of this transition are considered. It is necessary to place dangerous objects on a degree of danger, that is to pass to methodology of risk and gradually to invest necessary means. Per the last years quantity technogenous and nature-technogenous failures constantly grows. It causes peak loads on a national economy and, especially, on economy of regions. It is necessary to establish of acceptable risk level. There are two main peculiarities of an establishment of acceptable risk level in Russia: The risk levels in different regions differ rather essentially and it is impossible to apply already rather known methods. It is reasonable to set this size being based to a risk level now in particular region. For determination of an existing risk level in region is developed expert - statistical method based on medical-demographic mortality data from the unnatural reasons, quantity of dangerous industrial objects in region and long-term statistical parameters of damage from the natural phenomena.

TODAY’S SITUATION.
The Russian Ministry of Emergencies (Emercom) has accepted the decision on transition of management technogenous and natural safety on methodology based on risk. Russia - second
country after the Netherlands accepting such decision. In other countries of Europe and Northern America probabilistic methods are used as additional, as a rule, valid of the recommendations.

There is a natural question? Why in Russia till now not have more or less accomplished of a control system, based on deterministic methods, it is necessary to develop it with allowance for of risk technogenous both natural failures and accidents at a state level, being based on probabilistic methods. Certainly, the majority technically advanced countries do not hasten to follow an example of the Netherlands.

Now size of risk of death of the person from the unnatural reasons makes in Russia according to the statistical data $2 \times 10^{-3}$ (Without a part exogenous risk which is not reflected presently by statistics. With allowance for of this part the complete risk will be made about $3 \times 10^{-3}$). This value makes 13% from all reasons of death and almost in 10 times more, than in countries of Western Europe. (See. Fig.1.). It is necessary to note that on the first is disposed mortality from such reasons as murders and suicides. So for Moscow these data are indicated on Fig.2.

![Fig.2. Lethal accidents in the Moscow population. Percentage.](image)

**NECESSITY OF THE TRANSITION. THE SIMPLIFIED METHODS.**

There are a number of the reasons stipulated by historical development of Russia and its today's socio economic condition, inducing to transition on risk based a control system:

Within almost 70 years amortisation means for increase of safety of objects practically were not put. In result, the large part from 45 thousands dangerous objects in Russia does not meet the requirements of safety. The average level of mortality risk of the population from failures on them changes from $10^{-3}$ up to $10^{-4}$ (behind exception erected per the last years on modern requests ). Site of location, a technical condition and level of operation of these objects are so various, that the mortality risk of the population and drawing of damage to an environment from these objects can differ in 5 - 10 times for various regions of Russia. Such situation is not present in one technically to advanced country and even in developing countries (where the technical objects were delivered and were constructed with allowance for of modern requests.) The necessity of acceptance of immediate measures is obvious. But, also it is obvious, that the simultaneous realisation of necessary measures on all objects on increase of their safety is impossible on economic reasons (By some valuations necessary means for
modernisation of dangerous objects will make about 500 billions $. Hence, it is necessary arrange objects on a degree of risk, that is to pass on a risk basis of valuation of danger. According to a degree of risk received as a result of arrangement during 10 - of 15 years the measures on increase of safety on objects of regional and federal submission should be carried out. That concerns and to prevention of a death of the population and large damages, also to mitigation of consequences of natural, natural - technogenous accidents. 

It is obvious, that despite of planned and sold gradually during 10 - 15 years of a measure on increase of safety of objects and prevention of large damages of natural accidents, failure and the accidents will occur both during this period and after its ending. It will cause peak loads on a national economy and, especially, on economy of regions. An output from such situation is the introduction of system of insurance of dangerous objects and natural incidents. Necessary principle of management of safety is the establishment of a level of acceptable risk. In Russia there are two main peculiarity: the risk levels in different regions differ rather essentially. Also it is impossible to apply some known methods of an establishment of its size at once to all Russia. It is reasonable to set this size being based to a risk level now in particular region. This size at first is necessary for establishing by experts with allowance for of socio-economic condition of region on the certain interval of time. The risk level in region is determined by an expert-statistical method based on medical-demographic given on mortality from the unnatural reasons, according to WHO classification. For a number of regions o:

**Fig 3. Risk of the lethal technogenic and nature accidents**

On the basis of expert and statistical valuations by quantity of defeating persons, come on one mortal case in any extreme situation are determined total risk of a defeat and death. These data are submitted in a Fig. 4.

For management of risk it is necessary to know and risk of a material loss expressed in monetary units. Such valuations should take into account a material loss from death and defeat of the people, of damage from failures on industrial objects and on the transport and damage from natural accidents (which can received on the basis of valuations of Russian Academy of Sciences and Emercom). The data on material risks for Russia are indicated on Fig. 5. The valuations on some regions of Russia are submitted on Fig.6.
Bibliography.
The responsibility for population protection against industrial accidents and natural disasters lies with the local government. Thetefate its decisions on risk management are of vital importance.

One of most significant directions of administration of Sosnovy Bor city activities is the development of criteria, conditions and rules at planning development of territory, preparation of the decisions in the field of insurance of a civil liability of danger sources, drawing up of the emergency response plans.

Certainly, the solution of these questions is impossible without computer systems.

Lately the computer systems department of Sosnovy Bor administration has developed an ecological and economic system to support the decision-making procedure in the area of insurance of risks from potentially hazardous facilities. The system comprises a subsystem for the assessment of chemical risks. The IAEA guidelines and other methodical materials are used in this program. The electronic map of city is used based of geoinformation system ArcView 2.1b. All programs are written in language Avenue. Common urban databases: POPULATION and ENTERPRISES are connected to an electronic map of city.

The subsystem for risk assessment is used in the structure of common information space of Sosnovy Bor city. The existing corporate network allows use to resources of a local network by administration and enterprises of city.

Further it is possible to see the results of risk assessment of the main chemical dangers in city, the illustrations of an electronic map of city with zones of risks, function chart of interaction between administration of city, enterprises and supervising organizations are given.

For all of chemical dangerous industries in city the risk account on a technique of IAEA (Classification and prioritization of risk from accidents in technological processes and industrial manufactures, connected to them,) is carried out.

In particular there are as follows:

- Biological treatment station;
- Research Optical Institute - boiler-house;
- Urban boiler-house;
- Research Technological Institute - boiler-house;
- City Food storage - storehouse of ammonia

The given objects and zones of risk are given in figure 1. The electronic digital map of city is used.
All objects are stationary technological installations.

At account the main assumptions were:

- There are used only significant variable in an estimation of probabilities and consequences of accidents;
- Three typical categories of zones of risks are considered: a circle (at explosion), semicircle (at distribution of clouds of heavy gas), ellipse (at distribution of gas in an atmosphere).

The estimation of fatal consequences, i.e. amount of mortal cases among the population which are growing out of large accidents on each kind of dangerous activity was carried out. The analysis was made in view of the sizes of area, density of the population, with use of correction factors dependent on distribution of the population in area and softening consequences measures.

In particular for stationary technological installations the frequency of large accidents is estimated with use some average probable number (absolute size of the logarithm of annual frequency of accidents for the given activity) with addition of correction parameters which are
taking into account specificity of the given technology, and also level of its technical, organizational and natural security (degree of safety).

On each object the database including the following fields is made:

- The name of object;
- Amount of the lost people;
- Probability of accidents per one year;
- Dangerous substance;
- Amount of substance;
- Amount of struck objects.

The information on all considered objects has formed into the basis for construction of the diagram of risks (figure 2).

Such way we use the international experience in Russia.

Fig. 2 Diagram of risks

1. City Food storage - storehouse of ammonia;
2. Biological treatment station;
3. Urban boiler-house;
4. Petrol station;
5. Research Optical Institute - boiler-house.
The problem of political risk in Ukraine is one of the most actual up-to-date problems. Indeed, the changes in the world map at the end of the XXth century leads, on one hand to the breakdown of one of the most powerful states of the world, the Union of the Soviet Socialist Republics, and on the other hand to the creation of a number of new independent states (CIS). In this list, Ukraine occupies a special place. Its geographical location, natural resources, population and particularly its historically cultural and religious traditions are more close to European states. But the most distinctive feature of today is the unbalanced economy, the absence of clear strategic development plans or activation of military potential and the most important, a sharp geographical fight between the different parties. In the report presented, the sociological analysis of the political structure is done. The concrete facts of the political destabilisation are analysed. The criteria for the political risk assessment in Ukraine are proposed. The optimal political system model of Ukraine on the boundary of the new millenium is constructed.
ALTERNATIVE MECHANISMS OF MAJOR RISK INSURANCE: DERIVED INSTRUMENTS IN REINSURANCE

Fred CELIMENE and Myriam LANDEL
(CEREGMIA-Université des Antilles et de la Guyane)

As part of major risks’ management, it is necessary to compensate the lacks and disadvantages of the present compensation regime established by the laws of July the 12th, 1982. When the economical costs of the natural catastrophes are compared, wonders about the insurance playing its full role can be aroused. The present regime is based on the principles of solidarity and the intervention of the State as regards indemnification, what make it desincisitive as well for the insured as for the insurers. The insured that are not directly exposed to the risk and due to that fact do not suffer from big damages in case of natural catastrophe will have to pay for the insured presenting a high-risk probability. The insurers knowing themselves covered by the authorities can accept each kind of assured and relax the policies of prevention and the campaigns of incitation to self-protection. The existence of asymmetrical information between insured and insurer present in all insurance relationship take even more extent with the insurance of catastrophic risks. From a social point of view, it seems tricky to deprive someone from protection against major risk. We must encourage the insurance companies to put in place a private system of guaranteed reimbursement of the risk. In the objective, the alternative mechanisms of insurance are to our mind indispensable. They are in keeping with the logic of the division of risks and complete the recommended mutualisation in the classical contract of insurance. The institution, which finds itself behind this principle, is simple; it is a question of using as much possibilities of individual risk diversification. The development and the use of options on natural catastrophe risks of CBOT as mechanism of cover interested R. Litzenberg, D. Beaglehole and C. Reynolds (1996), M. Canter, J. Cole and R. Sandor (1996). Numerous works allow verifying the efficacy of the model for the United States (E. Briys (1998)).

The object of this presentation is to use the derived instruments on the French market as alternative mechanism of the traditional insurance. We will adopt the process of Litzenberg et al. and evaluate the optional cover of major risks through the derived instruments in reinsurance. We will pay attention to the management of the risks between insurers and reinsurers and define the different instruments used. After describing the strategies of retained covers, we will explain the main obtained results.

It is observed as it is the case in the United States that the reinsurance companies do not have the means looking at their financing surface to take charge of the totality of the catastrophes when they occur. A hurricane such as Andrew in 1992 reached the financing reserves of the insurers and reinsurers until considerably weakening the financing capacity of the whole reinsurance American market. In consequence, the raise of the demand concomitant to the decrease of the offer of the catastrophic risk reinsurance provoked a high tension on the reinsurance premium rates.

There are two methods of reinsurance risks cover. The first one consists in subscribing through a reinsurer to a proportional cover with a fixed amount for catastrophes. The second consists in subscribing to a cover for a part of the catastrophe (e.g.: 10 units), called « limits », which beyond this amount of catastrophe stays at the insurer’s charge (e.g.: 30 units) called attached point. It is called cover of catastrophes in excess. This way, beyond an amount of 30 catastrophes, the catastrophes situated between 30 and a maximum of 40 are at the reinsurer’s
charge. The premium paid in return by the insurer may be brought back to the « limit » to define the rate of reinsurance (Rate on Line). The futures on rating of catastrophes of reference thus represent a new category of financial instruments with its own characteristics. The call spread and the option of binary call allow the insurers and reinsurers to manage the risk market factor from their « major risks » portfolio.

The options on futures on rating of catastrophes of reference of the American market –CAT call spread- allow the carrying out of a cover strategy. The call, purchase option is a negotiable purchase contract on a bound support, in the case of the CAT call spread, the bound support is the rating of catastrophes. It grants its holder the right to buy a definite amount of bounds at a price fixed and designed which is the price of exercise. There is a possibility for the holder of the option to combine calls or put (options of purchase) and engage himself to strategies of arbitration. He constitutes an interesting strategy of cover in the measure where the maximal loss and the maximal gain stay limited. Each insurer has the possibility of choosing the call spread of cover that fits the best his insurance policies portfolio. Concurrently to the call spread, we will pay attention to another purchase option, the binary purchase option. In the case of binary call, it is observed that the option’s ceiling is contractual. It is freely negotiated. A call is said binary (0/1) because it throws a contractual flow when it is in the money and an empty flow when it is out of the money. Its function of result is discontinuous and proceeds a jump in the time. This new approach purely financial allows the insurer to cover himself in using the option of purchase on catastrophes rating. We will thus introduce the two types of derived instruments : the option of binary purchase (binary call) and the spread option of classical purchase (call spread).

The interest of our approach is to compare the rate of implicit reinsurance and the value of the option for the same cover of reinsurance. That way we will see what a cover or reinsurance in excess of 50 units cost, in using either a contract of traditional reinsurance or a contract of optional reinsurance. We consider then the securitization of reinsurance premiums and exposures in one-year debt security with an embedded CAT call option spread.

We can compare the techniques of traditional and optional reinsurance. The techniques of optional reinsurance present the advantage on the traditional ones of being cheaper for the insurer. For a level of cover in excess given (limits given), the insurer pays not the reinsurance premium but the option premium, that is to say the value taken by the option in a given situation. It is distinguished three situations: “out of the money”, “at parity” and “in the money”. We have seen that even in the situation when the option is the most expensive – when it is in the money- the option spread premium remains inferior to the implicit premium of reinsurance that the reinsurer would pay if he was opting for the traditional technique. In the case of binary call, it is preferable that the insurer subscribes his cover as long as the option is not yet in the money. In the insurer point view, the optional solution is then preferable.

From the reinsurer point of view, he is in the inverse situation to the insurer’s own. When he sells an option which value is inferior to the traditional implicit reinsurance premium, he records a loss of profit. However, when he sells a contract of option which is very in the money, the gain he is going to record is superior to the reinsurance premium when it is about a binary call. In general way, when the reinsurer sells a contract of options which is very in the money, he arrives to sell at height of 100% of the cover that he had proposed. In this case, he does not suffer any loss in case of the exercise of the contract of option by the insurer. We reach through this example of optional cover to seize the interest of the recourse to financial
This solution registers itself in a logic of partition of the risks complementary to the traditional mechanisms of insurance.

We can look at how the catastrophic bonds can interest the traditional investors. In this objective, we take the method developed by F. Black and R. Litterman (1991). The rule of partition of the catastrophic risks proposed by the recourse to the financial market is the following: distribute the risks between a huge number of investors. The exposition to catastrophic risk of the portfolio would be a low part of the total risk supported by the portfolio. This mechanism has for main advantage to drain the important backs and to allow a reduction of the specific risk of the portfolio "major risks" of the insurer. However, it does not allow to immunize against the inevitable risk of the portfolio. It is in adopting techniques of management of the systematic risk that we can finally immunize against this one.

The rate of nominal profit of catastrophic bonds being generally high, it would be a pity that the investors miss such an opportunity. All the more because the catastrophic bonds are not really correlated seeing negatively correlated with the regular financial actives. They procure then an evident interest in terms of diversification of portfolio. We calculate two types of coefficient of correlation: the correlation between the ratios of catastrophes at premium and the rate of profit of the obligations of the State. Secondly, the correlation between the ratios of catastrophes at premium and the rate of profit of the speculator indicia considered. The reimbursement rate of the principal of the catastrophic bond varies in the opposite direction to the catastrophe premium.

The interest of recourse to the financial markets is certain, it represents a source of financing supplementary coming to make up for the deficiencies of the private market of insurance in making intervene agents exterior to the insurance world. The possibility of appealing to financial markets remains a open matter but would need a certain time to be put in action. The recourse to financial markets is not very developed in France contrary to the United States that use derived products founded on the natural catastrophes.
Risk Analysis: Facing the New Millennium

define the price of reinsurance (i.e., the price is usually set through negotiations and is based on the risks involved). The insurance company calculates the risk premium based on the severity and frequency of losses, and the reinsurance company agrees to cover a portion of the losses in return for a premium. The premium is typically determined through negotiation between the insurer and the reinsurer, taking into account factors such as the insurer's risk profile, the type of coverage, and the market conditions. The reinsurer then invests in risk management strategies to mitigate the potential losses, which can include diversification, hedging, and other risk transfer techniques. This arrangement provides the insurer with a more stable and predictable income stream, as it is less exposed to the volatility of individual claim payments. The reinsurer, in turn, benefits from the spread of risks, which allows it to manage its overall risk exposure more effectively.

In the context of the global economy, the role of reinsurance has become increasingly important. The insurance market is closely linked to the financial markets, and the performance of reinsurance companies is closely watched by investors and regulators. The industry's ability to manage and mitigate risks is crucial to the stability of the financial system. As natural disasters and man-made disasters become more frequent and more costly, the demand for reinsurance increases, and the reinsurers play a vital role in ensuring that the costs of these events can be managed on a global scale.

We now consider the advantages of traditional and optional reinsurance. The decision to use optional reinsurance provides the flexibility to design a reinsurance program that is tailored to the specific needs of the insurer. Optional reinsurance allows the insurer to choose the level of coverage and the terms of the reinsurance agreement, which can be adjusted to fit the insurer's risk profile and financial objectives. This flexibility can be particularly valuable in times of market uncertainty, when the insurer may want to adjust its reinsurance strategy in response to changing market conditions. The use of optional reinsurance can also reduce the insurer's exposure to large losses, as the reinsurer bears a portion of the risk, thereby limiting the insurer's potential losses.

From the insurer's point of view, the use of optional reinsurance allows the insurer to manage its risk exposure more effectively. The insurer has the flexibility to design a reinsurance program that is tailored to its specific needs, which can help to maintain profitability and improve the insurer's financial stability. The use of reinsurance can also allow the insurer to expand its business into new markets, as it reduces the insurer's exposure to large losses, which can be a significant barrier to entry in some markets. The insurer can also use reinsurance to manage its liquidity, as the reinsurer typically provides a source of funding during large claim periods, which can help to stabilize the insurer's cash flow.

However, the use of reinsurance also introduces additional costs and management challenges, as the reinsurer is a separate entity with its own financial objectives and management practices. The insurer must also consider the potential for conflict of interest, as the reinsurer may have different incentives than the insurer. In addition, the use of reinsurance can increase the complexity of the insurance market, as it introduces a new layer of intermediation between the insured and the insurer. The use of reinsurance also requires careful risk management, as the reinsurer's ability to manage its own risk exposure is crucial to the success of the reinsurance agreement. The insurer must work closely with the reinsurer to ensure that the risk management strategies are effective and that the reinsurer is able to meet its obligations in the event of a large loss.
TRACK 4

SESSION 6

POLICY ASSESSMENT – COST BENEFIT
Session 6

Policy Assessment – Cost Benefit
FINANCIAL RISK ASSESSMENT OF A PORT DEVELOPMENT OPTIONS

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EQE International Ltd, 18 Mansell Street, London E1 8AA, UK

ABSTRACT
Risk analysis was carried out for an existing port catering for liquid and solid bulk trade, cargo trade, and passenger liners, and the proposed new port development that would take in liquid and solid bulk trade. Risk profile of fatalities, vessel losses, spillage and clean-up costs, tank farm and pipeline losses, has been carried out for the two cases. In addition, the effects of improving the Safety Management System (SMS) for the navigation in the port have also been investigated. The results for the overall risk profile show small reduction for the proposed development case, but a significant reduction in the case of the improved port SMS. While this result did not influence the decision making process, since the analysis of benefits have been excluded from this study, it shows contrary to the established views that a significant loss reduction (and decrease in the insurance premiums) can be achieved by introducing the proper risk based SMS in ports.

INTRODUCTION
The purpose of this study was to contribute to the decision making process about port development options. The existing port is catering for the liquid and solid bulk trade, cargo trade, and passenger liners; possible alternatives for the extension of the existing port installations were (a) to extend the existing port, and (b) to remove the liquid and solid bulk trade to a new port which would be sufficiently removed from urban areas to reduce inconvenience and the risk to urban population. The risk to be considered include fatalities, spills and clean-up, vessel damage and onshore facility (tank farm and pipelines) losses. Since the risk profile is evaluated for all traffic regardless of port, i.e. the existing port in case (a), and the existing and new ports in case (b), the overall risk reduction was not expected to be very significant, because the overall risk profile is improved by decreasing the number of vessel encounters in each port, and by improved conditions in the new port. Hence, the effects of an improved Safety Management System (SMS) for the two alternatives have also been evaluated.

RISK MODELS
A building block approach has been employed to facilitate risk comparison between the existing port and the proposed new development. In other words, for the marine operations hazards, the risk models were developed for the following vessel types:

- tankers
- bulk carriers
- general cargo, container and other ships
- passenger ships

All models have the same basic structure, with the main differences in the vessel number, spill capacity, cost of damage or loss, and the potential for fatalities. Similarly, for the hazards related to land operations, the risk models were developed for the following facilities:

- tank terminal
The list of initiating events for the hazards related to marine operations is shown in Table 1. The marine operations were split into seven phases as shown in Table 1, and the events relevant to each phase are marked by ‘x’. Each vessel risk model comprised a set of fault and event trees the quantification of which was carried out for each relevant phase of operations.

### Table 1  List of Marine Events

<table>
<thead>
<tr>
<th>Phase Name</th>
<th>Pilot boarding and initial approach</th>
<th>Connection of tugs</th>
<th>Manoeuvring with tugs</th>
<th>Berthing and mooring</th>
<th>At berth during loading/unloading</th>
<th>Unberthing</th>
<th>Escorting the vessel out of port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase No.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Initiating Event</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel collision</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Attendant vessel collision</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loading/overloading</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mooring failure</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navigation error</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilotage error</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of steering</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propulsion failure</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackout</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire manoeuvring error</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berthing/unberthing error</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cargo tank fire/explosion</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire in accommodation</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire in engine room</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire in pump room</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tug failure</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extreme weather</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2  Port Management Parameters

<table>
<thead>
<tr>
<th>System</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Control</td>
<td>Traffic rules</td>
</tr>
<tr>
<td></td>
<td>Navigational equipment</td>
</tr>
<tr>
<td></td>
<td>Number of pilots</td>
</tr>
<tr>
<td></td>
<td>Number of tugs</td>
</tr>
<tr>
<td></td>
<td>Traffic monitoring equipment</td>
</tr>
<tr>
<td>Organisation</td>
<td>Poor management practices</td>
</tr>
<tr>
<td></td>
<td>Lack of ship specific knowledge</td>
</tr>
<tr>
<td>Human</td>
<td>Poor decision making</td>
</tr>
<tr>
<td></td>
<td>Poor judgement</td>
</tr>
<tr>
<td></td>
<td>Lack of knowledge</td>
</tr>
<tr>
<td></td>
<td>Poor communication</td>
</tr>
</tbody>
</table>
A set of ‘port management parameters’ were incorporated into the marine risk model to reflect the effects of improving the SMS, as presented in Table 2. An audit approach of the management and organisation of the port control has also been carried out. The details of the risk assessment approach suitable to ports, and the link to the SMS for navigation, can be found in [1].

Marine risk models were also validated by comparison with the historical data, for example, for grounding and annual vessel/cargo losses.

RESULTS

The total expected annual loss for the existing port and the port with the proposed development, and the assumed level of traffic, was estimated as $21.9 million and $19.6 million, respectively. The reduction in risk for the proposed development option of 10% is mainly due to the reduced traffic, i.e. the reduced number of vessel encounters. All other conditions were assumed to be the same in both cases. Breakdown of the expected annual loss by risk source for the two cases is presented in Figure 1.

![Figure 1 Breakdown of Expected Annual Loss for Two Cases](image)

Significant risk reduction in pipeline related risks is due to the assumption that the pipelines in the proposed development are located far from urban areas.

The effects of an improved SMS on the two cases is presented in Figure 2. The expected annual loss in this case for the existing port and the port with the proposed development was calculated as $16.4 million and $10.3 million, respectively. This represents the reduction in risk of 25% for the existing case, and 53% for the proposed development case with respect to the existing port, and 39% with respect to the proposed development and the existing SMS. The additional risk reduction is mainly due to the assumption that the radar and other navigational equipment would be improved as well for the proposed development case.
CONCLUSIONS
It has been shown that this type of financial risk analysis can provide information about all potential liabilities, and also point the way to possible improvements. However, in this case the risk analysis results did not change the decision making process, as the benefits of the proposed development greatly overweigh the potential losses. However, contrary to the established view, the influence of a proper SMS for the navigation in ports has been shown to have a significant effect on the risk profile. It is shown that the annual reduction in the technical risk is of the order of $5.5 to $6.7 million, which is very likely much more that any spending on the development, implementation and management training required for the installation of a SMS. In addition, with a risk-based SMS it would be possible to provide evidence and demonstrate the case for the reduction in insurance premiums.

REFERENCES
Economizing and integration of the world have become one of the main regularities of the present-day historical stage. Under its influence a new global national economy is formed, which creates safety bases for both national and world development. The most complicated tasks in this relation are set for such “new market” countries as Russia, Ukraine, Kazakhstan and others. As a result of pseudo-economic reforms of last years, Ukraine has transformed into a country with a unique catastrophic strategy. One can compare that in 1990, according to classification of UNO, Ukraine belonged to elite group of industrial well-developed countries, now this is a country of the poor and beggars where the decline in the national production has reached more than 78% with respect to 1990. One can add to it that this situation, aggravated due to the process of closing Chernobyl Nuclear Power Station and corrupted powers, brings about the danger of far-reaching political, economical and social transformations of the country. The paper gives the analysis of financial crisis situations and their consequences. The problem of the influence of political risk upon the investment risk is discussed. The author describes promising directions of the management of the economic risk, as a political category.
A COMPARISON OF THE EXTERNAL COST OF HYDROELECTRIC AND NUCLEAR POWER PLANTS

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ABSTRACT
Environmental and health impacts and the associated damage costs of a medium size hydroelectric power plant, and a large nuclear power plant are assessed in this paper. A large number of impacts have been identified for both power plants. Occupational accidents, impacts on agriculture and forests, and noise produced during the operation of the plant, are the most important among hydro impacts. Concerning nuclear power besides the conventional impacts of the nuclear fuel cycle, the impacts of accidents during the electricity generation stage have been also assessed. The results of the analysis indicate that the major contributors to the damage cost of the hydroelectric power plant are noise impacts and fatal occupational accidents. Nuclear accidents contribute little to the external cost of nuclear power, while the most significant impacts are born in the non-power generation fuel cycle stages.

1. INTRODUCTION
The risks of electricity production, stem from a wide spectrum of health, environmental, and social impacts, and have been extensively studied in many countries. During the last decade efforts were initiated in order to evaluate these impacts, with emphasis on those that are not accounted for by the producers and consumers of energy, i.e. that are not included in the market price of energy, in a systematic, comprehensive, consistent and homogeneous way. These latter impacts are usually referred to as the external cost of the corresponding energy fuel cycle. Environmental and health impacts and the associated damage costs of a medium size hydroelectric power plant, and a large nuclear power plant are assessed in this paper. To this purpose a hydroelectric project along the Metsovitikos River in North-western Greece, and a nuclear power plant located on a hypothetical site in southeastern Evia Island, northeast of Athens, have been selected as reference. A large number of impacts have been identified, and impact estimations have been assessed.

2. DESCRIPTION OF THE REFERENCE SITES AND PLANTS
The sites of the reference plants are shown in Fig. 1. Concerning hydro a medium size plant in the mountainous area of Metsovitikos River in North-western Greece has been selected as reference(1). The dam of the hydroelectric project is about 1,160 m in length and 15 m height. This “earth fill” dam forms a reservoir extending over a surface of 11 ha with total water capacity of 200,000 m³. The hydroelectric power plant of Metsovitikos is going to be installed underground about 4.5 km downstream of the dam. It will consist of 2 units of 24 MW total capacity, with an average annual electricity production estimated at 63 GWh.

Concerning nuclear power and since most of the fuel cycle activities of a future Greek nuclear plant will be performed abroad, related results of the German ExternE study(2), for a 1375 MW nuclear power plant, which in turn employs French results in assessing impacts of nuclear fuel cycle activities performed in France(3), have been adopted. The impact pathway methodology has been implemented and the results of this analysis are summarily presented.
in the following. In addition a more detailed analysis of the impacts of reactor accidents has been performed concerning a nuclear power plant located on a hypothetical site in southeastern Evia Island in central Greece, and the contribution of these impacts to the external cost of nuclear power has been considered.

3. IMPACT ESTIMATIONS

3.1 Hydro power plant

Agriculture: The main impact on agriculture is the permanent loss of cultivated area due to the filling of the reservoir and the construction of infrastructure. A total area of 14.5 ha agricultural land will be impounded. The damage costs are estimated by the loss of local revenues due to the restriction of cultivated areas after the filling of the reservoir. The damage cost per unit of electricity produced has been estimated approximately at 0.423 mEURO/kWh.

Damages to Forestry: In the wider area of the project, flora is of high importance, specifically in altitudes over 1500 m. Significant forest ecosystems with oak-trees, bushes and holm-oaks cover 15.9% of the total area. The filling of the reservoir results on the flooding of 16 ha of forest area. Assuming an average annual revenue loss of 20.2-26 EURO/ha forestry area the estimated damage cost ranges within 0.0051-0.0066 mEURO/kWh.

Occupational Accidents: Concerning the construction activities there is a significant absence of an analytical data framework for occupational accidents of small size hydroelectric power plants. The occupational accident rates considered in this study refer to the whole Public Construction sector, and the average annual number of occupational accidents during this time period was estimated at 6,717 events. The distribution between fatal, major and minor accidents was 3%, 25%, and 72% respectively. The total damage cost has been estimated at 0.79-0.97 mEURO/kWh, and is given in Table 1 in more detail.

Noise: Implementing a methodological framework, which correlates noise emissions with the property values in the area, the noise impacts due to the operation of the Metsovitikos power plant have been assessed(1). The area in the vicinity of the power plant is densely populated and the total estimated damage cost is approximately 1.342 mEURO/kWh.

Impacts on Water Resources: The development of the hydroelectric power plant along Metsovitikos River, causes only limited interference in the water resources. The watertight geological formulations of the examined area restrict any interactions between the river body and the underground water resources. Concerning the surface water resources, the reduction of the mainstream flow results in aquatic environment alterations up to 5 km downstream of the dam. In addition, potential contamination of the river body during the construction activities due to greases and oil usage is temporary and insignificant.

Biological impact: Since, the Metsovitikos plant is a medium sized unit and the natural environment in its vicinity is not characterized by a high ecological value, only restricted interferences in flora and fauna are expected. More specifically, the construction activities result in local and small-scale vegetation alterations. In addition, due to noise and air pollution produced, some animals go away from the area. During the operation phase, the reduction of the mainstream flow and the existence of the dam result on biodiversity alterations in the reservoir area and in a part of the river, approximately up to 5 km downstream.
3.2 Nuclear power plant
The values for the front and the back end of the nuclear fuel cycle, and normal operation as well are presented in Table 2. In the accident analyses performed, the results of which as summarily presented in Table 3, five different nuclear accidents were employed to represent the spectrum of PWR severe nuclear accidents. The PWR accidents considered were based on the five representative release categories for the US Sequoyah nuclear power plant that account for a spectrum of possible containment failure modes: (a) very early containment failure during core degradation, (b) early containment failure at vessel breach, (c) very late containment failure including the basemat melt-through, (d) no containment failure, and, (e) containment bypass due to interfacing-system LOCA.

Table 2 Damage Costs of the Nuclear Fuel Cycle

<table>
<thead>
<tr>
<th>Power Generation</th>
<th>Damage Cost (mEURO/kWh)</th>
<th>Other Fuel Cycle Stages</th>
<th>Damage Cost (mEURO/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Operation</td>
<td></td>
<td>Public health</td>
<td></td>
</tr>
<tr>
<td>Public health</td>
<td></td>
<td>Radiological impacts</td>
<td>3.5</td>
</tr>
<tr>
<td>fatal cancer</td>
<td>0.059</td>
<td>Non-radiological impacts</td>
<td>0.56</td>
</tr>
<tr>
<td>non-fatal cancer</td>
<td>0.034</td>
<td>Occupational health</td>
<td>0.060</td>
</tr>
<tr>
<td>hereditary effects</td>
<td>0.020</td>
<td>Crops</td>
<td>0.00016</td>
</tr>
<tr>
<td>accidents</td>
<td>negligible</td>
<td>Ecosystems</td>
<td>not quantified</td>
</tr>
<tr>
<td>Occupational health</td>
<td>0.063</td>
<td>Materials</td>
<td>0.0077</td>
</tr>
<tr>
<td>Beyond design accidents (1)</td>
<td>0.0286</td>
<td>Noise</td>
<td>negligible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visual impacts</td>
<td>negligible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Global warming (2)</td>
<td>0.35</td>
</tr>
</tbody>
</table>

(1) 1375 MW PWR at the Platanistos site. (2) mid estimate with 3% discount rate

These accidents were postulated to occur in a 1375 MW PWR, sited on Evia island northeast of Athens. Health and economic impacts were estimated for the whole of Europe and European population. The radioactive inventory of the reactors was adopted from a BNL report by linear scaling of reactor powers. Health and economic consequence estimations were carried out by the MACCS2 computer code, which performs probabilistic calculations of potential offsite consequences of the atmospheric releases of radioactive materials in reactor accidents. The results of the accident analysis are presented in Table 3.
The monetization of health effects is based on the updated ExternE values\(^1\) of 3.1 MEURO for the value of statistical life, and the value of 0.45 MEURO for cancer injury.

### Table 3 Health and Economic Impacts of PWR Accident Spectrum

<table>
<thead>
<tr>
<th>Accident Identification</th>
<th>RSEQ-1</th>
<th>RSEQ-2</th>
<th>RSEQ-3</th>
<th>RSEQ-4</th>
<th>RSEQ-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident Frequency</td>
<td>2.8(10^{-7})</td>
<td>3.6(10^{-6})</td>
<td>1.2(10^{-5})</td>
<td>3.5(10^{-5})</td>
<td>3.1(10^{-6})</td>
</tr>
<tr>
<td>Early Fatalities</td>
<td>0.231</td>
<td>0.00107</td>
<td>0</td>
<td>0</td>
<td>0.0183</td>
</tr>
<tr>
<td>Early Injuries</td>
<td>166</td>
<td>45.865</td>
<td>0.4343</td>
<td>0</td>
<td>30.49</td>
</tr>
<tr>
<td>Cancer Fatalities</td>
<td>6010</td>
<td>2630</td>
<td>12.4</td>
<td>0.034</td>
<td>1690</td>
</tr>
<tr>
<td>Cancer Injuries</td>
<td>11300</td>
<td>4950</td>
<td>47.9</td>
<td>0.12</td>
<td>3200</td>
</tr>
<tr>
<td>Economic Costs (MEURO)</td>
<td>15700</td>
<td>5170</td>
<td>21</td>
<td>0.617</td>
<td>3222</td>
</tr>
<tr>
<td>Damage Cost (mEURO/kWh)</td>
<td>0.00276</td>
<td>0.01954</td>
<td>0.0001</td>
<td>0.00005</td>
<td>0.00618</td>
</tr>
</tbody>
</table>

### 4. CONCLUSIONS

By examining the results of Tables 1 and 2, it is obvious that the overall damage cost of the Metsovitikos hydroelectric power plant is significantly less than the corresponding cost of the Platanistos nuclear power plant. However it is noteworthy that the partial damage cost of the nuclear fuel cycle contributed by the power generation activities is very small, much smaller than the overall Metsovitikos damage cost, and it is only the radiological impacts of the activities of the non-generation stages that significantly increase, and dominate the overall nuclear fuel cycle cost.

### ACKNOWLEDGEMENTS

This paper is based on results of two research projects partially supported by the EC, DG XII, and the International Atomic Energy Agency, the contributions of which are greatly appreciated.

### REFERENCES

ABSTRACT

Very low influence of risk analysis on decision making in safety and environment protection could be observed in USSR and Russia until the end of 80-th. In 90-th the needs in practical use of risk analysis began to raise. They came from decision making on the rehabilitation, radiation and social protection of population on the territories suffered from the Chernobyl and other radiation accidents, nuclear weapon tests, etc. In the new economic conditions in Russia the issues of insurance against accidents and related topics (evaluation of damage from accidents, decisions on compensation, proper regulation, etc) appeal also to risk analysis. To meet these needs the development of methodical basis, computer codes and regulation began in the frame of research state programs. Some directions and results of this activity is described. They are: health risk assessment tool (general methodology and codes for any risk sources including the new proposal on standard risk indices and the additional risk index for establishing the universal safety standard, specific methodic part for radiation risk and health-demographic analysis), recommendations on economic risk analysis parameters, regulatory aspects of use of risk analysis in decision making, etc.

1. INTRODUCTION

Only research activity of some scientist’s groups in risk analysis with very low influence on decision making in safety and environment protection could be observed in USSR and Russia until the end of 80-th. In 90-th the needs in practical use of risk analysis began to raise. They came from decision making on the rehabilitation, radiation and social protection of population on the territories suffered from the Chernobyl and other radiation accidents, nuclear weapon tests, etc. In the new economic conditions in Russia the issues of insurance against accidents and related topics (evaluation of damage from accidents, decisions on compensation, proper regulation, etc) appeal also to risk analysis. To meet these needs the development of methodical basis, computer codes and regulation began in the frame of research programs of Emercom, Minatom, Ministry of Public Health (MPH) and State Committee on Environment Protection (SCEP) of Russia. Coordinating Council on risk analysis in nuclear industry and power (Minatom) and Committee on risk assessment and management (MPH and SCEP) were established in 1997/98. R & D began with increasing intensity in many state and non-governmental research institutions. Raising amount of papers presented on the last few SRAE conferences reflects this situation in Russia.

RRC "Kurchatov Institute" is involved in R & D risk analysis activity in the programs mentioned above. This activity includes development of risk assessment tools (methods and computer codes) and regulation. Some directions and results of this activity is described. They are: health risk assessment tool (general methodology and codes for any risk sources including the new proposal on standard risk indices and the additional risk index for establishing the universal safety standard, specific methodic part for radiation risk and health-demographic analysis), recommendations on economic risk analysis parameters, regulatory aspects of use of risk analysis in decision making, etc.
2. ON THE HEALTH RISK ASSESSMENT TOOL

This tool (the methodology and computer code and database (BARD: bank of data on risk analysis)) has been continuously developed using new achievements and responding to raising practical demands [1-3]. The tool consists of the general part, applicable to any risk source, and few specific parts with additional sections for concrete risk sources (radiation risk, health risk from chemicals, health risk from social-economic factors, etc.).

Here only the proposal on development and practical use of “standardized” risk indices (SRI) is shortly described. This proposal comes from necessity to overcome problems known with practical application of the risk assessment results which are connected with effects of risks competition and using the current health-demographic data, see, e.g., [2,4]. Some ideas along this line one can find in [4].

We propose to introduce into practical use a “standard population” with steady-state and equilibrium features. For such population a survival function \( H'(a) \) is equal

\[
H'(a) = \frac{n'(a)}{n'(0)},
\]

where \( n'(a) \) is the age distribution for this standard population. It means that for any risk source \( i \) standardized mortality index \( \mu_i \) usually used in the health-demographic analysis, is proportional to lifetime risk \( R_i^s \):

\[
\mu_i = \int_0^\infty n'(a)\mu_i(a)da = n'(0) \int_0^\infty H'(a)\mu_i(a)da = n'(0)R_{i}^s.
\]

\( \mu_i(a) \) is the age-cause specific mortality rates for risk source \( i \). For age \( e \) standardized lifetime risk \( R_i^s(e) \) and loss of life expectancy (LLE) \( G_i^s(e) \) are equal respectively

\[
R_i^s(e) = \int_0^\infty H'(e,a)\mu_i(a)da,
\]

\[
G_i^s(e) = \int_0^\infty H'(e,a)\mu_i(e,a)T'(a)da, \quad T'(a) = \int_a^\infty H'(a,a')da'.
\]

WHO standard populations used in the health-demographic analysis are not in the steady-state equilibrium. But there are no any serious reasons against some insignificant changing the age distribution of the standard population to give the steady-state feature to it.

So slightly changed WHO standard population could be used as an unified basis for the health-demographic and health risk analysis.

3. REGULATORY ASPECTS OF RISK MANAGEMENT

Practical application of risk analysis needs in respective regulation documents. In the last few years the draft documents and recommendations has been elaborated. They contents the general recommendations on using risk analysis, demands to the risk assessment and analysis methodology and computer codes, recommendations on using causation probability approach, recommendations on safety standard and decision making risk levels etc. (see [5] and its citing).

3.1. Universal risk index and safety standards

To protect population or personnel from dangerous industry activities the risk limits are usually established in the terms of individual mortality rate \( r \). It is obvious that such limits
can't be properly used for the risk sources with delayed health effects (ionizing radiation, impact of some chemicals especially with carcinogenic or hereditary effects, etc.).

For radiation protection ICRP proposed a generalized risk index $R_E$ in which different health effects and their measures are combined (lifetime mortality and morbidity risks, respective LLE, etc.) [6]. On the basis of this risk index the effective dose $E$ is constructed. $E$ is used for establishing dose limits as a safety standards. Really these standards can be considered as a risk limits. But $R_E$ being the generalized risk index is nevertheless specific for radiation risk and can't be directly used for comparison with other risks.

After discussions on the aspects of establishing safety standards in risk indices, analyzing the risk indices and ways of their integration for different risk sources, especially ICRP recommendation [6] the proposal was elaborated concerning the universal risk index $R$ for establishing safety standards. Quantitatively $R$ is defined as the partial mathematical expectation of LLE referred to a year under “exposure” of risk source considered:

$$R = \begin{cases} 
  g_r \cdot r & \text{for risk sources with non-delayed effects,} \\
  g_E \cdot d_E & \text{for ionising radiation.}
\end{cases}$$

(4a)  
(4b)

Here $r$ is mortality rate, $g_r$ is averaged LLE due to a non-delayed death ($g_r = 35 - 40$ years); $d_E$ is dose rate (annual effective dose), $g_E$ is well-known LLE risk coefficient for the ionizing radiation ($g_E = 1 \text{ man*year/Sv}$). From this definition one can see the meaning of $R$. It is relative LLE: LLE in years referred to 1 year under the risk (dimension of this value is [year/year]). For chemical cancerogens one can write the formula for $R$ analogous to (4b). These definitions can be also generalized for morbidity.

Using this risk index the universal safety standards (risk limits $R_n$) can be established. Our proposal is the following:

$$R_n = \begin{cases} 
  0.001 & \text{for public,} \\
  0.015 & \text{for personnel.}
\end{cases}$$

(5)

One can see that the secondary radiation protection standards - effective dose limits - derived from (4b) are equal 1 and 20 mSv/year respectively for public and personnel. For risk sources with non-delayed health effects the derivative risk limits in the terms of death risk rate $r$ are equal

$$r_n = \begin{cases} 
  3 \cdot 10^{-5} / \text{year} & \text{for public,} \\
  5 \cdot 10^{-4} / \text{year} & \text{for personnel.}
\end{cases}$$

(6)

"De minimus" level $R_{d.m.}$ for public is proposed to be established as $R_{d.m.} = 10^{-5}$. Respectively the secondary "de minimus" levels for public should be $r_{d.m.} = 3 \cdot 10^{-7} / \text{year}$ (risk sources with non-delayed health effects) and 10 $\mu$Sv/year (ionizing radiation).
3.2. Basic risk indices
In dependence of applications of risk assessment (estimation of risk from different risk sources including accidental situations, optimization of protection measures, insurance and payment of compensation for damage etc.) the following set of health risk indices is recommended to use:

- loss of life expectancy (LLE) - for population health damage assessment, overall optimization of protection measures;
- life time or annual death risk (R) - for decision making levels, insurance;
- relative LLE 91 (see above) - for safety standards;
- probability of causation PC - for decision making on causation links between irradiation and cancer disease of death and compensation;
- individual DI and collective SI equivalent exposure doses to red marrow-
- individual DI and collective SI partial effective doses (without dose to red marrow) -
- cases of death or disease (non-stochastic health effects of radiation exposure) - for population health damage assessment from accidental exposure (pre-accident PRA);
- individual DE and collective SE effective doses - radiation protection mainly in normal or close to normal situations.

3.3. Costs of risk
Considering the economic aspects of risk analysis and management the following costs (α) of the risk indices described above are recommended:

\[ LLE \rightarrow \alpha = 50 \text{ Euro/man-day,} \]  
\[ R \rightarrow \alpha = 20 - 40 \text{ Euro for the risk unit } 10^{-4}, \]  
\[ S_I \rightarrow \alpha = 20 - 40 \text{ Euro/man-cSv,} \]  
\[ S_E^p \rightarrow \alpha = 20 - 40 \text{ Euro/man-cSv,} \]  
\[ S_E \rightarrow \alpha = 200 \text{ Euro/man-cSv.} \]

Minimal compensation for damage (loss of life or heavy disability) is proposed to be equal 100,000 - 200,000 Euro.

It is necessary to distinguish possibilities in assessment of risks or damages a priori and after the accident. In the first case the damage can be estimated only in general form - without specific details. In the method of damage evaluation for stochastic health effects from radiation exposure two parts in the collective dose are reasonable to distinguish: \( S_I \) (leukemia) and \( S_E^p \) (solid cancers). It should be obvious that the economic estimation of damage from the second part, referred to the accident time is less by the order of magnitude than the first one.

In the second case estimation of damage after an accident can and should be done in details using the risk assessment. It is necessary for decision making on intervention, compensation etc.
4. SOCIAL-ECONOMIC SOURCES OF HEALTH RISK

One of the lessons learned from the Chernobyl and other post-emergency response (PER) is necessity to consider radiation as well as non-radiation risk sources including those of social-psychological and social-economic nature. The social-psychological impact on the population health as a negative consequence of the non-perfect PER on the territories suffered from the Chernobyl accident has been studied in many research projects. But in these and other concrete PER one should also take into account the very serious negative health consequences of the political and economic changes after 1990 in all regions of Russia. Some data on this aspect are presented on Fig. 1.

![Graph showing annual standardized mortality for Russia population (EU for comparison) in different years due to all death causes (a), circulatory system diseases (b), accidents and adverse effects (c)].

Fig 1. Annual standardized mortality (per $10^5$ people) for Russia population (EU for comparison) in different years due to all death causes (a), circulatory system diseases (b), accidents and adverse effects (c) (European standard population of 1992; BARD calculation, input data from [7,8])
These consequences are very much higher than all possible radiological and non-radiological health effects of the accident or nuclear weapon tests on the territories suffered. One of the main reasons of this changing in population health of Russia is the social desadaptation of people (more concrete explanation can be found in [8]).

So considering decision making on the rehabilitation, radiation and social protection of population on the territories suffered from the Chernobyl and other radiation accidents, nuclear weapon tests, etc., in the context of the most efficient PER it is necessary to assess by a unified way - through the risk analysis - the state of health as a whole and the radiation and non-radiation risk factors.

5. CONCLUSION

To meet the raising practical needs in risk analysis in the last few years R & D activity began in the frame of research state programs of Minatom, Emercom, Ministry of Public Health and other governmental organizations of Russia. Some draft regulatory documents and recommendations, methods and computer codes have been elaborated. Now the process of their adaptation and approval by the authorized bodies started. One can wait that this process will be very hard. As usual one of the most controversial point is the proper treatment of uncertainties in decision making.

REFERENCES


DEVELOPMENT OF MATHEMATICAL MODELS AND SOFTWARE FOR ECOLOGICAL AND TECHNOCENIC SAFETY CONTROL

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ABSTRACT
The aim of this work includes the development of computer technology for valuation of risk of origin and forecasting of consequences of irreversible changes at different levels of organization of ecological systems, the definition of optimal control of liquidation of negative consequences of ecological and technogenic accidents, the definition of critical levels of a intensity of regulative restoring gears and reserves of systems, on reaching of which the risk of ecological accidents grows sharply. Distinctive feature of the proposed approach is valuation of risk of ecological accidents (REA) with the help of a vector of states of an ecological system. Components of the vector are variables of three types, describing levels of recreation opportunities, intensity of recreation gears (IRG) and reserve opportunities (RO) of a system. They are estimated with the help of various mathematical models. The valuation of risk of origin of ecological accidents is carried out by means of smooth function theory, enabling to determine critical values of IRG and RO, on reaching of which the ecological system suffers irreversible changes. A measure of the risk is a degree of approaching to this critical value.

The model was used to solve some problems of optimum redistribution of resources with the purpose of minimizing decreasing material resources. Optimization problems were solved by a method of casual search. The multi-criterion statement of a problem were considered, to find an optimum control, which would permit to balance changes of parameters, describing ecological system's load and its reserve possibilities, maximize the level of manufacture and quality of life, on the one hand, and minimize risk of accidents and level of pollution, on the other. The results were utilized for estimation of efficiency of various ways of normalization of economic situation when East-European countries integrate into the European community.

Optimization problems of minimization of risk of accidents and maximization of life quality

In work [1] a model of global dynamics was offered, which in version presented by [2] looks as follows:

\[
\begin{align*}
\frac{dP}{dt} &= P(B_\text{M}B_\text{P}B_\text{D}B_\text{Z} - C_\text{D}D_\text{M}D_\text{P}D_\text{Z}), \\
\frac{dZ}{dt} &= PZv - (Z/T_\text{Z}) - (VU_\text{Z}/C_\text{Z}) \\
\frac{dR}{dt} &= -PZM + (VU_\text{R}/C_\text{R}), \\
\frac{dS}{dt} &= (1 - U_\text{S}) S_\text{F}S_\text{Q} - S/T_\text{S}, \\
\frac{dU_\text{S}}{dt} &= C_\text{M}(1 - U_\text{R} - U_\text{Z})V/P
\end{align*}
\]

where

- \( P \) - amount of population; 
- \( V \) - funds (capital funds); 
- \( Z \) - level of environment pollution; 
- \( R \) - resources; 
- \( S \) - share of funds in agriculture; 
- \( U_\text{R}, U_\text{Z} \) - accordingly, shares of funds, directed on restoration of resources, on struggle with pollution; 
- \( U_\text{S} \) - parameter, describing control of investments in agriculture; 
- \( M_\text{S} \) - material level of life; 
- \( C_\text{B}, C_\text{D}, C_\text{M}, C_\text{P}, C_\text{R}, C_\text{V}, C_\text{Z}, T_\text{S}, T_\text{V} \) - parameters of model; 
- \( B_\text{M}, B_\text{P}, B_\text{D}, B_\text{Z}, D_\text{M}, D_\text{P}, D_\text{F}, D_\text{Z}, R_\text{M}, S_\text{F}, S_\text{Q}, T_\text{Z}, V_\text{M}, Z_\text{V} \) - function, which is determined on the basis of the analysis of empirical data and are set in the form of table.

In works [3-4] the mathematical model for risk assessment of ecological and technogenic accident was developed. Distinctive feature of the proposed approach is valuation of REA with the help of a vector of states of an ecological system. Components of the vector are
variables of three types, describing levels of: a) recreation opportunities, b) intensity of recreation gears, and c) reserve opportunities of a system. Their calculation is carried out with the help of dynamic ecology-economic model, based on Forrester's consideration [1]. The valuation of REA is carried out by means of cusp deformation of catastrophe theory, enabling to determine critical values of parameters and describe levels of intensity of regulative systems and their reserve opportunities, on reaching of which the ecological system suffers irreversible changes.

Let us use the results [1-4] for development of the model for calculation of critical values of levels of pollution and ecosystem's reserves and risk control. However, the model requires some updating. At first, as the dynamics investigated in work [1] was global, the considered system is closed one. Researches of regional dynamics should take into account flows, binding considered region with external world. Secondly, in model [1] some integral environment pollution was considered, while the research of negative consequences of Cherno-byl accident a radioactive component should be distinguished in the general pollution. Let us modify the model (1) using additional terms $I_k (k = P, V, R, Z)$, describing a sum of flows of variables into a system and to the external environment, into the right parts of appropriated equations of model (1). To estimate the influence of radioactive pollution on birth and death rates of population, on quality of foodstuffs, on exception from industrial and agricultural activity of a part of the industrial enterprises and land areas we also modify table set functions $B_p, B_z, D_p, D_z, S_p, S_Q$.

The mathematical statement of a problem is formulated as follows: a system described by equations (1) - (2) is given, the solution of the Cauchy's problem is to be found on time interval $[0, T]$ for a given set of parameters of the model.

In work [3] model (1-2) was used to solve some problems of optimum redistribution of resources with the purpose of minimization of decreasing material resources. $U_R$ and $U_Z$ respectively, shares of the capital, directed on restoration of resources and on struggle with pollution were chosen as control effects; $U_S$ is a parameter, describing control of investments in a agriculture. In that case the multi-criterion statement of a problem was considered.

The purpose of this work is determination an optimum control, which would permit to estimate the efficiency of various ways normalization of economic situation during Ukraine integration into the European community. Let's introduce aditional parameter of control $C_V$ - capital investment generation normal. In this case the problem of optimum control of risk can be formulated as follows: the mathematical model for valuation of risk and forecasting consequences of ecological and technogenic accidents (1) - (2), the system of limits, determining possible range of changes of model variables and control effects are given; it is required to find the control effects $U_R (t)$, $U_S (t)$ $U_Z (t)$ and $C_V (t)$ which minimize the functional:

$$F(U_R, U_S, U_Z, C_V) = A_1 C_P / I_P - A_2 C_P m_P + A_3 C_{Z2} I_2 + A_4 (\max Z / Z_0 - 1) + A_5 \frac{Z}{Z_0} + A_6 C_R / I_R + A_7 C_{RISK} I_{RISK} + A_8 C_M S / I_M S + A_9 C_{MS2} m_{MS} - A_{10} (1 - Q / Q_0) + A_{11}(1 - F_R / F_R) - A_{12} C_{FRM} e_{FR}$$

(3)

Where - $A_i, i = 1, 12$ weight coefficients; $C_P, C_{P2}, C_R, C_{RISK}, C_{Z1}, C_MS1, C_MS2, C_{FR}$ - multipliers, permitting to balance the contribution of each term in objective function;
Risk Analysis: Facing the New Millennium

\[ I_p = \int_{t_0}^{t_k} P(t) dt, \quad I_z = \int_{t_0}^{t_k} Z(t) dt, \quad I_R = \int_{t_0}^{t_k} R(t) dt, \quad I_{RISK} = \int_{t_0}^{t_k} RISK(t) dt, \quad I_{MS} = \int_{t_0}^{t_k} M_S(t) dt, \]

\[ m_p, m_{MS}, m_{FR} \text{ - minimum values of derivative of an appropriate values on the interval } [t_0, t_k]; \]
\[ Z_0, Q_{10}, F_{R0} \text{ - initial values at the moment } t_0; \]
\[ \max Z \text{ - maximum values of a level of pollution on a interval } [t_0, t_k]; \]
\[ Q, Q_I, F_R \text{ - value of sizes at the moment } t_k \]

\[ Q = Q(M_S, F_R, Z, P), \quad F_R = F_R(P, Z, S), \]  

here \( Q \) and \( F_R \) - table set functions describing, respectively, life quality and food levels.

The optimization problem was solved by method of casual search [1,2] (fig 1).

Fig.1

The circles corresponds to real data for Ukraine, on which the solution of identification task was carried out. The curve 0 corresponds to solution of dynamic task at fixed control
influences. The curves 1-4 accordingly represent solution of optimization tasks, objectives of which accordingly were: 1 - minimization of risk and maximization of life quality; 2 - minimization of risk and maximization of life quality and value of funds; 3 - minimization of risk, pollution, mortality level and maximization of life quality and value of funds.

Estimation of efficiency of various ways of normalization of economic situation during Ukraine integration into the European community

As it is visible from figures, the solution of the task 1 practically not differs from dynamic modeling beside more high life quality. The solution of the task 2 has appeared unsatisfactory because of a high level of pollution, which results in growth of mortality and accordingly to sharp decreasing of population. More optimal results are achieved for the optimization tasks 3 and 4. The highest population and lowest risk corresponds to these solutions. At the end of modeling interval (from 2005 year) there is a growth of GNI and life quality. And for the task 4 these parameters are higher, than for the task 3.

The appropriate control influences are represented on fig. 2.

![Fig.2](image)

It is necessary to note that among all control parameters the strongest influence on achievement of a minimum of functional 3 renders $C_v$. It testifies that at existing limitations the simple redistribution of funds it appears insufficient for stabilization of situation in society.

Thus task of normalization of economy of Ukraine can not be solved without changes of $C_v$. As carried out model researches have shown, these changes can not be achieved due to foreign investments or credits. Only cardinal changes in the legislation, connected with introduction of private property on land, stimulation of privatization and development of small business will allow to achieve increase $C_v$. As it is visible from fig. 2 solution of the task 1 is achieved by faster growth $C_v$, whereas the tasks 3 and 4 - slower. It is connected that at solution task 3 and 4 lots of funds are spent for solving problem of social character, therefore less means remains on conversions in economy.

REFERENCES


TRACK 4

SESSION 7

POLICY ASSESSMENT – GLOBAL PERSPECTIVES & NATURAL DISASTER
TRACK 4

SESSION 7

POLICY ASSESSMENT

GLOBAL PERSPECTIVES ON NATURAL DISASTER
NEW PERSPECTIVES FOR BUSINESS CONSULTING IN THE RISK MANAGEMENT OF NATURAL DISASTERS AND GLOBAL CHANGE

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ABSTRACT. Usually there is little incentive for economic actors to protect the environment, which manifests itself in the form of negative external effects resulting in unsustainable economic development. In the field of natural disaster risk, however, Risk Management by businesses aided by consultants may provide positive external benefits, as businesses by reduction measures automatically reduce risk for the surrounding environment as well. More benefit is achieved by consultants in their function as information intermediaries by increasing the value of existing information and adding new information. As a tool for Risk Management Consulting we introduce the Blue Box Tool.

1 GLOBAL CHANGE AND EXTERNAL EFFECTS

1.1 Global Change and Natural Disasters. Globalisation has far-reaching impacts on society and businesses. Businesses and governments have to act in global contexts with new and unknown chances but also increased competition and risks. A subgroup of these risks constituting the down-side of globalisation can be subsumed under the term Global Change: phenomena are an increased vulnerability of society due to the increase of assets and the use of complex technologies, urbanisation trends, population rise in the less developed world and a growing degradation of the environment. A consequence of these trends is the rise of natural disasters caused either by the growing deterioration of the environment (climate change, clearcutting of the rainforest etc.) or by socioeconomic causes affecting vulnerability. As a result, damages due to natural disasters are on the rise in an exponential manner: over the last three decades economic damages have increased by the factor 9 and insured damages by the factor 15 (deflated values) (1).

1.2 External Effects. From an economic and legal point of view the cause for a major part of Global Change phenomena is that most environmental goods like water and air are public goods, which are characterised by the existence of non-rivalry (i.e. the use of the good by one person does not affect another person's possibility for using it) and non-exclusivity (no one can be excluded from using it). The consequence is that there is no incentive for using these goods efficiently, as user costs have not to be borne by the user. Thus these goods are overused creating environmental problems. Effects arise which are called external (2). As indicated, external effects are usually of a negative kind, may however also be positive. In the last few years there has been strong discussion about how to react appropriately to Global Change threats and provide modern society and future generations with a long-lasting and forwardlooking way of living and conducting business, which has come to be called Sustainable Development. A way of dealing with the risk of catastrophic outcomes of "Unsustainability" is Catastrophe or Risk Management.

2 RISK MANAGEMENT AND SHORTCOMINGS

2.1 Risk Management. The term Risk Management originated in the insurance sector and means an optimisation of the risk portfolio of a (insurance) company. In a broader sense it can however be defined as "the sum of risk reduction measures conducted by government
institutions, companies or individual persons aimed at reducing, channelling and regulating risk" (3). Risk Management is on the one hand a responsibility of government to bring about a sustainable future, on the other hand a duty for companies to secure long-lasting profit for its shareholders and jobs for its employees. This paper investigates some potentials for bringing together social and private Risk Management approaches.

2.2 Shortcomings. As shown, there is a growing need for Risk Management, however today's Risk Management methods and approaches are often not up to the challenges (4,5):

- emphasis is mainly put on post-event management instead of a holistic approach comprising both preventive and postevent measures,
- a global view and understanding of the long duration of the examined processes is lacking,
- the focus is on rebuilding instead of building in a sustainable manner,
- the amount and availability of data is insufficient,

There are countries like the USA and Scandinavia where these issues are better put to practice, but mostly today's Risk Management of natural disasters is still insufficient. As the major part of the responsibility of reducing risk lies with government, which however in many countries is subject to ever declining fiscal resources, a lot of these tasks cannot be undertaken properly. On the other hand, influence and importance of companies, especially of transnational ones, is growing. And, the treatment of global change and potential natural disasters becomes more and more a long-term task for companies. In times to come these aspects should be part of strategic management reasoning and of the so called Economics of Strategy (6). So, there is room and need for government-business alliances in the fight against natural disaster risks.

3 THE MODEL

3.1 Consulting and Business Consultants. An important institution bringing together government and businesses are business consultants. Business consultants work in different areas: There are strategic business consultants, consultants in reinsurance companies, internal consultants and consulting done by universities. What could be the task of consultants in the context of natural disasters?

Consultants are usually experienced in data collecting and problem analysing, they act as information intermediaries. Another important aspect is that they are in close contact with their clients, which other institutions, like for example governmental agencies, usually are not. Additionally, consultants often have good economic knowledge in the way that they are able to say, if a solution is economically efficient or not. The efficiency aspect in the context of natural disasters becomes more and more important as resources are getting scarcer.

Also, it is important to be aware of the fact that consultants have an impact that goes beyond pure consulting work. Consulting units of for example McKinsey or Boston Consulting - to name just two of many - with concepts like the portfolio concept (7) influence the way of thinking of their clients. Consultants promote the globalisation in the sense that they use and promote such tools world-wide. Thus they are change agents in the age of globalisation.

3.2 The Blue Box Tool. The goal of introducing the Blue Box Tool concept is twofold. It supports the risk management of natural disasters. And if it is used by world-wide operating consultants, it helps to shape the awareness for natural disasters, like the portfolio concept shaped the awareness for market strategies. There are however two questions to be answered: Who pays the business consultants? How could the Blue Box Tool look like?

Consultants help clients to reduce damages and risk exposure by providing information and benchmark strategies. Therefore it is rational for businesses to pay the consultants to the extent of benefits achieved. Additionally, if disaster risk is reduced everybody having been
exposed to it gains, also government agencies exchanging information with the consultants. What is more, consultants could help these agencies to present the information in the worldwide web. The web offers especially for poor countries - where unfortunately most of the natural disasters occur - great opportunities, because it provides an up-to-date information access for low budgets.

The Blue Box Tool is an instrument that brings together different layers of information and helps to determine the individual risk exposure. In a second step it can be used for strategic decision-making. A Blue Box is used in the movie industry to produce one movie by blending several others. To give an example: A movie of the desert and another movie which shows a cowboy riding on a horse. The resulting movie would then show a cowboy riding through the desert. This principle of bringing together different pictures to get a new one is also used in the Blue Box Tool, which combines different disaster relevant aspects of nature: flows resulting from the media air, water and earth. At the end of the analysis the individual risk situation can be determined (in figure 1: point A with high risk exposure).

From an economic perspective one acts rational, if one tries to reach a situation with a low disaster probability and low damages. Some risk management measures reduce the first and some the latter aspect. With the Blue Box Tool it is possible to analyse different scenarios and choose the best one under the given preferences (this is indicated in Fig. 1 by movements from point A to B, C or D).

3.3 External Benefits. In a macroeconomic and systemic perspective, disaster risk consulting can also provide external benefits to the other economic actors government and households, as the collective receives and uses environmental flows which simultaneously constitute a certain level of disaster/environmental risk. Benefits here may be achieved in two ways:

1) As a company reduces risk in its immediate surroundings (e.g., by building a flood dam) protection for others living in that area is automatically provided.
2) Although consultants provide the specific risk information for companies not cost-free, they give away general information freely, as this constitutes part of the co-operation with public institutions providing them with data. At the same time, consultants ameliorate quality and value of these public data by standardising and providing it to the public. This information may then form part of national or global open-access disaster risk reduction information institutions like the Global Disaster Information Network (GDIN) or the Disaster Relief Network.

4 CONCLUSIONS
Usually there is little incentive for economic actors to protect the environment, which manifests itself in the form of negative external effects resulting in an unsustainable manner of economic development. In the field of natural disaster risk, however, risk reduction by businesses aided by consultants may provide positive external benefits, as businesses by reduction measures automatically reduce risk for the surrounding environment as well. More benefit is achieved by consultants acting as information intermediaries as they increase the value of existing information and add new information of general interest which is regularly collected by companies. In this way, consultants and businesses in the future may actively contribute to the challenge of reducing risk and impacts of natural disasters.
ENDNOTES:


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VARIED SCALE'S ASSESSMENT OF VULNERABILITY OF OBJECTS
IN THE PROCEDURE OF NATURAL HAZARDS RISK ANALYSIS

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ABSTRACT
The vulnerability value of objects is necessary for prediction of risk from natural hazards (NH). Assessment of physical vulnerability of objects under influence NH begins with the classification of elementary objects, which fulfils accounting of objects' scale and NH type. The main parameters of objects classification are: their disposition and orientation, area, number of floors, function of edifice, capacity, degree of material's depreciation, material of construction, existence of protective measures.

The assessment of vulnerability includes inspection of objects, which were damaged by NH, and engineering analysis of inspection’s results. Inspections are carried out on the special methodic. Its purpose is determination of type and degree deformations of constructional elements of edifice. Received assessment allows creating tables of vulnerability in which assessments of vulnerability for different type objects of varied intensity NH are contained. At present tables of vulnerability for earthquakes, underflows, and floods are prepared.

The assessment of vulnerability territorial objects is beginning with dividing territory into comparatively homogeneous areas, which equally respond to negative influence of certain NH. It makes possible to give description of object’s vulnerability versus NH with required detailed elaboration, which correspond to scale of investigation. From the beginning, the following main parameters of territory utilization are recommended for distribution: industrial, agricultural, demography, urbanistic, transport, recreating, natural-resource. According to every parameter we separate the territory into districts in the result of which taxones are formed. That taxones are characterized by equal type economy activity and have the same specific value of employment and the same reaction on the influence of NH, having definite genesis and intensity.

Further, we continue to detail elaborating objects for the purpose of having the more concrete parameters of employment, which are related to single house, edifice and its homogeneous total combination. Thus, we have the possibility to make assessment of vulnerability for the territorial objects on the base of vulnerability tables for elementary objects.

The assessment of vulnerability of objects to natural hazards is the second stage of the general procedure of risk analysis after or (simultaneously) with the assessment of the hazard of processes. The vulnerability represents a prediction evaluation of possible damages of an object as a result of natural hazards effects expressed in comparative physical, economical and other indices of losses. One the one hand, the vulnerability value depends on the type and intensity of a negative external effect On the other hand, the vulnerability as the property of an object depends on its structure and state.

The vulnerability assessment of elementary objects stems from the selection and analysis of statistical data on the events happened, the mathematical and physical modeling as well as experts’ assessments. It is advantageous to represent the vulnerability values in the form of tables listing data of the vulnerability degree of different objects which conform to the various intensity of the hazardous process as negative process effects upon the objects are very
different and directed to various parts of the facility. Details of the vulnerability tables are varied depending on the investigation scale and the available material of observations. It is desired that the tables have a regionally oriented nature which is defined by a list of objects most peculiar for this region. Examples are found in the vulnerability tables for the objects located on the Russian Coast of the Caspian Sea and exposed to seismic shocks, wind and wave pileups and underflows which were developed by us.

The vulnerability can be assessed in various aspects: physical (material) vulnerability, economical, social and environmental one.

With the assessment of the vulnerability of a complex object consisting of a number of varied elements (for example, a district of the town, an industrial facility and others) it is necessary to structurize the object: 1. to separate similar elements of the object uniformly responsive to negative effects of hazardous processes; 2. to predetermine a specific significance of each elementary object in the system of the complex facility.

The vulnerability of a complex object is assessed as an average value of vulnerabilities of elementary objects weighted by their specific significance. The specific significance can be obtained by different ways. Experts can evaluate the significance of each element from the point of view of its reliable functioning in the system of combined parts of a technically complex facility. The specific significance of elementary objects in the system of the territorial facility is determined according to a share of the territory occupied by elementary objects of each type on the entire territory. The evaluation of the cost of elementary objects is used in the assessment of economical vulnerability of a complex facility. This is shown by the table in which the relationships of cost of individual structural elements of the facilities of various types are given.

When investigating territorial objects, especially in drawing up maps of vulnerability and risk, the assessment of the territory vulnerability should begin with typization of the territory by the kind of its utilization. In this case taxones are formed which are characterized by a quasihomogeneous type and level of utilization, uniformly responsive to a specific negative effect. For example, with the assessment of the city vulnerability to seismic effects areas uniform in the structure of facilities, a number of floors and the wall material are separated on the city territory. For the underflow process taxones of zoning are determined by a structure type of the underground part of a facility (the availability and type of a basement, the kind and material of a foundation, etc).

Further the structurization of the taxones separated is made as a result of which a list of objects located on the taxone territory is composed. These are transport facilities? the engineering infrastructure, services, as well as recreations in our case.

The total assessment of vulnerability of the taxone represented in such a way is estimated as a weighted average of assessments of physical vulnerability of each elementary object with due regard for a share of the object in the total area of the taxone or in the total cost of the national value.

In the assessment of social risk including also the drawing up of maps of social risk the territorial evaluations of social vulnerability are made in the following way. The vulnerability of an individual man depends on his physical state and the circumstances under which he exists: the duration of his residence in the facilities exposed to a negative effect and the vulnerability of the facilities referred to. At the present time tables are available which establish the relationships between the people vulnerability and the damage degree of facilities in case of catastrophes. Using the data of these tables it is possible to calculate a value of social vulnerability of a group of people as a result of natural hazard within one object which takes into account the duration of residence of people during a day and year.
The territorial assessment of social vulnerability is determined with allowance made for the relation between the number of objects of different types and the vulnerability of people within these objects in much the same way as the total assessment of material or economical vulnerability presented above.
EXPERT MENTAL MODELS OF ECOSYSTEM RISK

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ABSTRACT
Experts play a leading role in defining the criteria by which risks are evaluated. In this role, their personal values and beliefs often come into play and are expressed through the use of metaphors and mental models of risk. Mental models of risk are not solely matters of individual cognition but also correspond to world views, deeply held beliefs and values about society, its functioning, and its potential fate (Dake 1992.) Three generic world views have been identified that may explain why experts have different mental models of ecosystem risk (Kempton et al. 1995, Thompson et al. 1990).

Three mental models of ecosystem risk dominate the literature. The carrying capacity model is based on the assumption that experts can determine the optimal rate of resource consumption or waste discharge that an ecosystem can absorb (e.g. Rees 1995). The focus of the biological integrity model is the conservation of natural self-regenerating communities of species (e.g. Angermeir & Karr 1994). The ecosystem health model tries to safeguard ecosystem functions and services critical to our well-being (e.g. Costanza et al. 1992.)

Repertory grid methodologies will be used to elicit and compare expert mental models of ecosystem risk. Gaines and Shaw (1989) have developed online techniques and algorithms that can be used to map and display the elements, attributes, and values used to characterise ecosystems, and to clarify the underlying distinctions. For the ecosystem approach to become a reality, it will be necessary to reconcile conflicting mental models of ecosystem risk and build a new consensual paradigm, that could help decision makers evaluate future policy choices.

BACKGROUND
An ecosystem perspective is appealing to policy makers who want a multi-issue, place-based approach to decision making. Before we can think and act in terms of ecosystems, we must reconsider the role of expert risk perception and judgement in ecological risk assessment. While the language of ecology has captured the public's imagination, it has failed to become the language of public policy because ecologists do not share a common view of the functioning of nature or the role of humans in it. There is considerable controversy about the nature of ecosystems, and their importance to our survival. In spite of the controversy, this concept is increasingly being incorporated into environmental legislation as either a policy goal or management approach.

An ecosystem consists of a dynamic complex of biological communities and the physical habitat that sustains them. It is the smallest natural unit of the biosphere that can sustain life over the long term. The ecosystem perspective provides a broad systematic overview of the interaction among the chemical, biological, and physical components of the environment (E.C. 1994.) It explicitly recognises thresholds of change where ecosystems will change in form and function, and involves the use of ecological boundaries for the assessment and
management of issues. In recent years, there has been widespread recognition that resources must be managed as dynamic integrative systems, because the physical, chemical and biological components of ecosystems are interdependent. Moreover, the ability of ecosystems to sustain life must be protected (Johnson 1988.) If the productivity of farm, forest, lake and marine ecosystems is not protected, people will not be able to obtain the necessities of life (Kimmins 1992.)

Ecosystem concerns engage us only when more fundamental life domains or core values are threatened: our health and well-being; our standard of living; our way of life; our fundamental understanding and expectations of the world around us (Eyles 1996.) Without clear policy goals it will-nigh impossible to set priorities and to strike an appropriate balance between ecological, human health, and welfare concerns. Within resource management agencies there is only a limited consensus about what ecosystem components and attributes should be protected (U.S. EPA 1994.) As well, there is a need to define resource use and conservation goals that reflect a better understanding of how people affect natural processes at a regional scale so that resource managers would be better able to meet public expectations.

Ecological risk assessment is goal driven. A comprehensive conceptual framework is needed to guide ecological risk assessment that is acceptable to a broad range of disciplines. Everyone agrees that ecological risk assessments should assure the value of ecosystems (Suter & Bartell 1993) but we have no policy-relevant classification of valued ecosystem components and attributes, nor a consensus about how to measure and represent them (Commission on Risk Assessment and Risk Management 1997; Menzie-Cura & Assocs. 1996.)

Our system of governance is setup to reconcile different interests, not differing views of reality. Without a shared frame of reference, experts cannot compare or trade off possible policy options. Moreover, if stakeholders or the public do not share the experts' perspective, the force of logic and more facts will not move them. The ecosystem approach provides a vantage point from which to critique and redirect older forms of policy and organisation. As an emergent paradigm, however, it lacks a process for building public consensus about the goals of ecosystem management, for defining and measuring important values, and for evaluating the weight of evidence.

EXPERT MENTAL MODELS AND WORLD VIEWS

When experts talk about ecosystems, they use a variety of metaphors and mental models of risk that reflect fundamentally different preoccupations. Each of these mental models of risk is based on a distinct set of beliefs about the driving forces of change, decision making and what is important and worthwhile about nature. (See Table 1.) Metaphors are popular images or beliefs about what the world should be like and what people think is moral, desirable, and just. Mental models are built from our own experience and consist of a limited set of assumptions or distinctions that we apply to a particular domain to solve problems and anticipate future events. They are the filters through which we see the world. Different mental models of the same phenomena are not always mutually exclusive, and in some cases represent a continuum of thought and action.

Experts live and work in very different occupational and institutional contexts which engender distinctive ways of looking at the world and representations of what constitutes risk (see Kempton et al. 1995.) Three generic world views have been identified that may explain to
Table 1: Expert Mental Models of Ecosystem Risk

<table>
<thead>
<tr>
<th>MENTAL MODEL</th>
<th>Carrying Capacity</th>
<th>Biological Integrity</th>
<th>Ecosystem Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metaphor</td>
<td>Limits to Growth</td>
<td>Wilderness preservation</td>
<td>Medical diagnosis</td>
</tr>
<tr>
<td></td>
<td>Ecological footprint</td>
<td>Conservation ethic</td>
<td>Sustainable development</td>
</tr>
<tr>
<td>Focus of Concern</td>
<td>- amount of resource</td>
<td>- naturally self-regenerating native species</td>
<td>- ecological services and</td>
</tr>
<tr>
<td></td>
<td>consumption or waste</td>
<td>typical of area</td>
<td>functions important to human health</td>
</tr>
<tr>
<td></td>
<td>discharge that can be</td>
<td>- natural variability, and</td>
<td>&amp; economic welfare of communities</td>
</tr>
<tr>
<td></td>
<td>safely absorbed</td>
<td>interconnectedness of habitat</td>
<td></td>
</tr>
<tr>
<td>Decision making</td>
<td>Optimal - Sustainable</td>
<td>Natural benchmarks</td>
<td>Holistic- Social values and</td>
</tr>
<tr>
<td>criteria</td>
<td>yield or threshold limit</td>
<td>Safe minimum standards</td>
<td>goals - Multiple criteria</td>
</tr>
<tr>
<td>Driving forces</td>
<td>Pollution &amp; waste,</td>
<td>Species extinction,</td>
<td>Population growth,</td>
</tr>
<tr>
<td>of change</td>
<td>resource depletion</td>
<td>loss of habitat</td>
<td>consumption, lifestyle</td>
</tr>
</tbody>
</table>

some extent why experts have different mental models of ecosystem risk. (Slovic & Peters 1998, Dake 1992, Thompson et al. 1990.). Underlying these world views are different values, myths of nature, notions of learning, risk taking, regulation, the role of experts and resource management (see Table 2.)

Table 2: World views

<table>
<thead>
<tr>
<th>WORLD VIEW</th>
<th>Hierarchical</th>
<th>Egalitarian</th>
<th>Individualist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values</td>
<td>Social &amp; Altruistic</td>
<td>Aesthetic &amp; Moral - Equity</td>
<td>Utilitarian - What is good</td>
</tr>
<tr>
<td></td>
<td>Greatest good for the greatest number</td>
<td>and fairness to future</td>
<td>for individuals will benefit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>generations, security</td>
<td>society as a whole</td>
</tr>
<tr>
<td>Myths of Nature</td>
<td>Tolerant - Perverse</td>
<td>Fragile- Catastrophic</td>
<td>Robust -Cornucopian</td>
</tr>
<tr>
<td>Learning - Decision Making</td>
<td>Defer to experts - rational quantified decision making</td>
<td>Precautionary - rights-based moral imperatives</td>
<td>Holistic- trial &amp; error stakeholder negotiation</td>
</tr>
<tr>
<td>Risk Taking</td>
<td>Risk / Benefit - opportunity cost for creating wealth, a stronger society, and a safer future</td>
<td>Risk Adverse - continued economic growth will ultimately lead to social and environmental disaster</td>
<td>Risk Takers - growth and innovation leave people better-off in the long run</td>
</tr>
<tr>
<td>Control/ Regulation</td>
<td>Bureaucratic regulation - command and control</td>
<td>Community involvement - co-operation</td>
<td>Well-functioning markets - negotiation &amp; competition</td>
</tr>
<tr>
<td>Role of Experts</td>
<td>Map &amp; manage boundaries of acceptable risk</td>
<td>Misuse scientific knowledge in short sighted ways</td>
<td>Creativity &amp; Innovation is necessary to our survival</td>
</tr>
<tr>
<td>Social Concerns</td>
<td>Social disorder - Maintenance of status quo</td>
<td>Inequality- Need for social change</td>
<td>Personal freedom - Opportunity for gain</td>
</tr>
<tr>
<td>Resource Mgmt.</td>
<td>Can manage resources but not needs.</td>
<td>Can manage neither resources nor needs.</td>
<td>Can manage resources and needs.</td>
</tr>
</tbody>
</table>

ELICITING MENTAL MODELS OF RISK
When experts are working in a domain where a consensus has not yet been achieved, it is important to be able to compare their conceptual structures (Gaines & Shaw 1989) without forcing a false consensus on the group and to bring to light differences in their viewpoints. Repertory grid methodologies provide an effective way to indirectly elicit an expert’s mental model without imposing a particular conceptual structure on the respondent (Shaw & Gaines 1992.) Respondents are asked to specify all the entities in the domain (e.g. valued ecosystem components), to make dichotomous distinctions among them, naming these distinctions, and classifying all the entities in terms of them. This set of distinctions and the relationships among them, distinguish one expert’s mental model of the domain from another.
RepGrid is an object-oriented data base providing an integrated set of tools for the elicitation and analysis of repertory grids (CPCS 1993.) It combines a number of different tools for element and construct elicitation; clustering; exchange and comparison of different grids; and an inductive rule generation program. I am using RepGrid to find out whether experts have different mental models of ecosystem risk and if these mental models reflect different world views in order to help resolve conflicting approaches to decision making about ecosystems.

REFERENCES


WHO PAYS FOR CATASTROPHES?

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ABSTRACT
In 1998, catastrophic natural disasters claimed the loss of around 50,000 lives, and estimates of economic damage are in the range of US$ 90 billion, the second highest annual financial loss in history. Reported figures on catastrophe losses, however, often do not reveal the ultimate beneficiaries of risk reduction and transfer. Even if largely non-quantifiable, it is important to gain a better understanding of how uninsured losses reverberate through the local community, the tax-paying public, the national economy, international financial markets, lending institutions, and future generations. This paper identifies those who absorb the losses of natural disasters, with special attention to the case of Poland following the disastrous 1997 floods, and examines why a large percentage of these losses has been uninsured. It also examines the benefits and costs of catastrophe bonds and other novel insurance instruments for spreading losses to the global capital markets.

INTRODUCTION
In 1998, catastrophes claimed the loss of around 50,000 lives, and estimates of economic damage are in the range of US$ 90 billion, the second highest annual financial loss in history (Munich Re, 1998). The rising worldwide costs of catastrophes can be explained mainly by increasing concentrations of populations, capital and fragile infrastructure in hazard-prone areas. Because of the enormous disparity in the GDP, the per capita cost of natural disasters in relation to GDP in the developing world has been estimated to be 20 times higher than in the developed countries (Freeman, 1999).

The reported figures on global catastrophic losses, however, do not include indirect losses nor do they reveal who ultimately bears them (U.S. National Research Council, 1999). Even if largely non-quantifiable, it is important to gain a better understanding of how the direct and indirect losses reverberate through the local community, the tax-paying public, the national economy, international financial markets, lending institutions, and future generations.

SPREADING DISASTER LOSSES
Insurance is perhaps the most important social institution for transferring costs to a pool of insured policyholders and to investors. Although considerably higher than in the developing world, the extent of insurance coverage in industrialised countries, especially for earthquakes and floods, is remarkably low (Swiss Re, 1997). The vast majority of catastrophic exposures faced by corporations, businesses and households are self-retained (see Froot and O'Connell, 1997). This is also true for European transition economies. In Poland, for example, only around 10 per cent of the public was insured at the time of the devastating flood damages in 1997 (International Federation of Red Cross and Red Crescent Societies, 1998). Insurance, of course, is not affordable by the world's very poor, but the question arises why a significant proportion of losses from recent natural catastrophic events in the U.S. and Europe has been uninsured? Because of the dependent nature of the claims and problems of maintaining sufficient liquidity (and the relative high probability of occurrence in the case of floods),
catastrophic risks often present an unacceptable risk of insolvency (Jaffee and Russell, 1997). Issues of ambiguity, adverse selection, and moral hazard add to insurers' business risks (Kunreuther and Roth, 1998). Moreover, the demand for insurance appears to be influenced more by social/perception factors than individual estimates of cost and benefit (Palm, 1998).

Viewed world-wide, international disaster relief plays an even smaller role than insurance in spreading the global burdens of natural catastrophes (International Federation of Red Cross and Red Crescent Societies, 1998). As reported by the United Nations Disaster and Humanitarian Aid Agency, international disaster aid for Poland after the 1997 floods covered only about one per cent of the total direct losses. Moreover, responding to the victims of a natural disaster inevitably diverts funds from other victims, frequently those of military conflict. A more significant role is played by international lending agencies, such as the World Bank and the European Bank for Reconstruction and Development, and these and other agencies gave low-interest loans to Poland in 1997 covering over 20 per cent of the flood losses. In repaying these loans, the losses will be transferred to the Polish tax paying public and to future generations. Poles. Another unintentional way for transferring losses away from the direct victims of natural disasters is through financial institutions. In Bangladesh, for example, the Grameen bank reports large defaults on its small-scale micro loans after flood events (Yunus, 1998).

With limited private/public insurance and international aid, ex post intervention by the government to compensate and aid victims in the case of a catastrophic event is a reality in most of the world, including countries with mature insurance markets. In the U.S., the average expenditure by the federal government for disaster assistance is significantly greater than the average annual loss borne by reinsurers on US catastrophe coverage (Froot, 1997). In Poland, for example, the extensive government relief program after the flood in 1997 amounted to about a third of direct losses. Post-disaster government relief also imposes burdens on diverse groups depending on how the funds are financed. Tax increases, as one financing mechanism, entail a cross subsidy from the non-victim community to the victim community; guaranty funds, as another mechanism, may penalise groups holding other types of insurance policies; budget diversions victimise the beneficiaries of other government programs; and public borrowing may pass the burden on to future generations.

Another aspect of disaster loss accounting, which is often not fully appreciated, is the role of local and national governments. Governments not only compensate private victims, but they can suffer enormous losses to public infrastructure – roads, communications, water treatment plants, and so forth. In Poland, over 40 per cent of the direct losses from the 1997 flood were to government infrastructure (Kunreuther and Linnerooth, 1999). Yet, very few governments are insured, and public infrastructure losses are usually covered by issuing new debt instruments, taxes, or diverting funds from other budgeted items. Especially for poor countries with fiscal or other constraints on borrowing, governments may default on international obligations. The World Bank estimates, for example, that during the past decade up to 35 per cent of its lending for infrastructure projects in Mexico has been diverted to finance disaster relief (Freeman, 1999).
HEDGING INSTRUMENTS FOR PUBLIC FINANCING?

The important point is that there are many direct and indirect losers resulting from natural disasters, but despite a large insurance and reinsurance industry and international charitable aid, the major share of the losses in both rich and poor countries appear to remain with the immediate victims and their governments. Surprisingly, however, few individuals, firms or governments are well prepared to finance these potential disasters. Because of the large and double role governments play in absorbing losses, this paper addresses the possibilities for greater public risk transfer. In addition to traditional post-disaster financing instruments, a government can transfer or hedge its catastrophic risks either by purchasing traditional insurance or issuing insurance-linked securities, such as catastrophe bonds. A catastrophe bond is an instrument whereby the investor receives an above-market return when catastrophes do not occur, but shares the insurer’s or government’s losses by sacrificing interest or principal when catastrophes do occur. With catastrophe bonds or other capital market instruments, insurers (and governments as insurers) can pay to transfer catastrophe risk to global investors.

The size of the US capital market alone is in the order of US$ 26 trillion (Insurance Services Office, 1999), which could easily absorb the global losses from natural disasters. However, there are costs to governments and private firms of transferring these losses either with traditional insurance or with catastrophe bonds. Froot and O’Connell (1997) contend that the premium of catastrophic insurance is considerably above its actuarially fair price and added brokerage fees. Recently, however, the premiums for catastrophic loss coverage offered by the insurance and reinsurance industry have been declining due to the large amounts of funds available for providing protection (Freeman, 1999).

The efficiency and fairness of these instruments to poor and emerging-economy countries will, therefore, depend on their cost, how the costs are distributed, and the country’s alternatives for raising post-disaster capital. With very large damages, such as in the recent case of Honduras, the country will likely require funds for recovery far beyond the capacity of its conventional financing sources. For these “mega” disasters, there are clear advantages to taking steps in advance by purchasing hedging instruments. Moreover, the attractiveness of these hedging instruments will increase if they encourage cost-effective measures for reducing the losses from disasters.

Since very poor countries, however, are likely to have difficulties in paying the price of protection prior to a disaster, attention should be given to designing “ex ante aid packages” or subsidizing the purchase of hedging instruments for countries facing catastrophic disasters for which they will have difficulties financing an appropriate response. As suggested by Kunreuther and Linnerooth (1999), international lending institutions might also consider innovations for subsidizing these payments.

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THE USE OF RISK MANAGEMENT FUNCTION IN THE OPTIMIZATION OF TERRITORY PROTECTION WHEN PREPARING REGIONAL CHARTS

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In the last few years floods, hurricanes and other natural hazards have had a severe impact on the economy of Europe and caused a lot of victims amongst the population. In Russia the area of floods reaches 400 thousand square kilometers, that amounts to 2.5% of the territory of the country, thus creating the threat for 750 cities.

When preparing regional protection charts it is necessary to solve the problem of the optimization of protection, i.e. to find such amounts of capital investments in carrying out engineering-protection measures that do not exceed the value of impact caused by natural hazards and their consequences.

This problem may be solved by the way of plotting the risk management function. The function, for example for the case of compiling an antiflood protection chart, will represent a dependence of the following type:

\[ R = f(\Delta H), \]

where \( R = P(H) \times D(H) \), where \( R \) is the risk of damaging a territory (in US$), \( P(H) \) is the repeatability of hazardous level of water, \( D(H) \) is the damage (in US$), \( \Delta H \) is the raising of territory marks (in meters).

Simultaneous plotting of dependences \( C(\Delta H) \) and \( R(\Delta H) \), where \( C \) is the capital investment, makes it possible to determine the value of \( \Delta H \) at which the capital investment is numerically equal to the risk. It should be noted that the proposed method of the optimization of protection helps to solve a complicated problem pertaining to the choice of the statistical assessment. This assessment is taken into account by the designers when they prepare charts of antiflood protection - 1% frequency level.
TRACK 5
SESSION 1

CHERNOBYL - DOSIMETRY
THE USE OF RISK MANAGEMENT FUNCTION IN THE OPTIMIZATION OF TERRITORY PROTECTION WHEN PREPARING REGIONAL CHARTS

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In the last few years floods, cyclones and other natural disturbances had a severe impact on the economy of Europe and caused a lot of victims amongst the population. It follows that the sum of flood-related 400 billion square kilometers, that amounts to 2.5% of the territory of the country, thus creating the threat for 750 citizens.

When preparing regional maps of risk management function holds the problem of the optimization of projects, i.e., the effective arrangements in carrying out engineering-technical solutions that will not exceed the value of impact caused by natural hazards and their compensation.

This problem may be solved by the way of plotting the risk management function. The function, for example, for the case of creating an anti-flood protection chart, will represent a dependence of the following form

\[ R = f/(D1) \]

where \( R \) = risk, \( f \) = factor, \( D1 \) = damage (in US$). PIPD is the responsibility in the form of level of value, \( D1 \) is the damage (in US$), \( D2 \) is the volume of territory threats (in hectares).

For example, plotting of risk management function, i.e., the risk level of the natural environment makes it possible to determine the value of \( R \) of which the expected development is economically equal to the risk. It should be noted that the proposed method of the estimation of risk, helps to solve a complex problem, pertaining to the estimation of the natural environment.

The measures to ensure your security by the designers when they develop charts of anti-flood protection - is the frequency level.
RETROSPECTIVE DOSIMETRY OF SOME POPULATIONS EXPOSED AFTER CHERNOBYL

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Full paper see page 894
ABSTRACT.
Uncertainty due to parameter variability in ingestion thyroid dose assessment made using adapted to local radioecological Belarusian conditions food chain model has been evaluated. Determination of the sensitivity of models to the parameters and uncertainty of model predictions have been conducted by applying of a Monte Carlo method with Latin hypercube sampling. As a result, the uncertainty factors 2.6-2.8 are estimated for thyroid doses calculated using the model.

INTRODUCTION
After the Chernobyl accident there was a sharp increase of thyroid cancer incidence among those who were exposed during childhood or adolescence in Belarus [1]. A case-control study performed in Belarus indicated a strong relationship between thyroid cancer and radiation dose from the Chernobyl accident [2]. Excess absolute risk and excess relative risk of thyroid cancer have been estimated in [3] on the basis of large-scale thyroid dose reconstruction in Belarus, Ukraine and Russia, and observed thyroid cancer incidence in those countries.

One of the important tasks in risk assessment is the quantitative uncertainty analysis. Uncertainties in thyroid doses are the large contributors to the resulting uncertainty in estimated post-Chernobyl thyroid cancer risk. Therefore, to improve the risk assessment of late effects of thyroid exposure, the uncertainty analysis of thyroid dose estimates must be performed. Results of uncertainty analysis show the reliability of model predictions and give the stochastic values that has to be taking into account if the risk estimation is based on the results of such model.

Model based on the activity transfer through the environmental to human with parameters adapted to local area-specific conditions was applied for thyroid dose assessment in Belarus. Exposure of population from ingestion of contaminated by $^{131}$I milk and leafy vegetables is considered within the model. Those pathways were the most important for thyroid exposure to Belarussian population. Detail discription of model can be found elsewhere [4,5]. As a result the deterministic values of age-dependent average thyroid doses have been calculated for the considered settlements. However reconstructed thyroid doses are associated with uncertainties arising from the following main sources: (a) modeling uncertainties due to simplification in model the dose formation process; (b) uncertainties of extrapolation of model; and (c) uncertainties due to variability of model parameters. The main aim of the paper is to evaluate the quantitative uncertainty of thyroid dose estimates used for thyroid cancer risk assessment.

METHOD
In the given work uncertainties of model prediction due to variability of model parameters (parameter uncertainty analysis) is considered. Uncertainty analysis was conducted according to the recommendations [6] and included the following main stages:
- Evaluation for each model parameters type of distribution and probability density function;
- Revealing of correlation between parameters of a model;
- Evaluation of a probability density function of model prediction;
- Ranking of parameters of a model under their contribution to resulting model uncertainty (sensitivity analysis).

Uncertainty analysis has been performed using a numerical Monte-Carlo method. For each model parameter the probability density function was calculated according to the mathematical model. This procedure was repeated N times (in the given work N = 10000) and, thus, the representative distribution of N values of thyroid doses was obtained. The calculation were performed using the software Crystal Ball® [7].

To perfomed sensitivity analysis the sensitivity index and rank correlation coefficient have been estimated for each model parameters. Sensitivity index was estimated according to the [8] as:

\[ SI = \left| 1 - \frac{D_{\text{min}}}{D_{\text{max}}} \right|, \]

where \( SI \) – sensitivity index;
\( D_{\text{min}} \) and \( D_{\text{max}} \) – model prediction when parameter has minimum and maximum value, Gy.

### Table 1. Model parameters and their probability density functions.

<table>
<thead>
<tr>
<th>Model parameter</th>
<th>Units</th>
<th>Probability density function</th>
<th>( x_{\text{av}}(x_{50}) )</th>
<th>( \sigma (\beta) )</th>
<th>( x_{2.5} )</th>
<th>( x_{97.5} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground deposition</td>
<td>( GD_{131} ) * kBq·m(^{-2})</td>
<td>ln</td>
<td>1.0</td>
<td>0.5 (1.7)</td>
<td>0.35</td>
<td>2.9</td>
</tr>
<tr>
<td>Initial interception</td>
<td>( f^* ) rel.</td>
<td>ln</td>
<td>1.0</td>
<td>1.1 (2.5)</td>
<td>0.15</td>
<td>6.3</td>
</tr>
<tr>
<td>Vegetation yield</td>
<td>( Y ) kg·m(^{-2})</td>
<td>u</td>
<td>0.27</td>
<td>0.05</td>
<td>0.18</td>
<td>0.36</td>
</tr>
<tr>
<td>Grass intake by cow</td>
<td>( I_g ) kg·d(^{-1})</td>
<td>u</td>
<td>40</td>
<td>6</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Soil intake by cow</td>
<td>( I_s ) kg·d(^{-1})</td>
<td>u</td>
<td>1</td>
<td>0.3</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Upper soil layer depth</td>
<td>( H_s ) m</td>
<td>u</td>
<td>5·10(^{-3})</td>
<td>1·10(^{-3})</td>
<td>2.5·10(^{-3})</td>
<td>7.5·10(^{-3})</td>
</tr>
<tr>
<td>Density of upper soil layer</td>
<td>( \rho_s ) m(^{-3})</td>
<td>u</td>
<td>1·10(^{-3})</td>
<td>6·10(^{-2})</td>
<td>9·10(^{-2})</td>
<td>1.1·10(^{-1})</td>
</tr>
<tr>
<td>Feed-to-milk transfer</td>
<td>( FF_m ) d·L(^{-1})</td>
<td>ln</td>
<td>2.3·10(^{-3})</td>
<td>2.1</td>
<td>5·10(^{-4})</td>
<td>1·10(^{-3})</td>
</tr>
<tr>
<td>Elimination of (^{131})I from milk</td>
<td>( \lambda_{\text{m}} ) d(^{-1})</td>
<td>tr</td>
<td>0.81</td>
<td>0.10</td>
<td>0.63</td>
<td>0.99</td>
</tr>
<tr>
<td>Elimination of (^{131})I from grass</td>
<td>( \lambda_{\text{agr}} ) d(^{-1})</td>
<td>n</td>
<td>0.067</td>
<td>0.016</td>
<td>0.035</td>
<td>0.099</td>
</tr>
<tr>
<td>Delay in pasture period</td>
<td>( \Delta t_{\text{pd}} ) d</td>
<td>u</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Delay in leafy vegetable</td>
<td>( \Delta t_{\text{ld}} ) d</td>
<td>u</td>
<td>0</td>
<td>4</td>
<td>-7</td>
<td>+7</td>
</tr>
</tbody>
</table>

* Given parameters have different absolute values, therefore here indicated multiplying factors applied to default values. Type of distribution: ln=log-normal; n=normal; u=uniform; tr=triangular.

For the important radioecological parameters the probability distribution functions have been estimated on the basis of empirical values obtained in Belarus following the Chernobyl accident. Characteristics of distribution were evaluated using maximal likehood method. The
validation of selected type of distribution and empirical data is performed using Kolmogorov-Smirnov criteria and $\chi^2$ criteria. In the given work for the description of parameter's distribution the following values were used: mean ($x_{av}$) or median of distribution ($x_{50}$), standard deviation ($\sigma$) or geometric standard deviation ($\beta$), 95% confidence - 2.5 and 97.5 percentile of distribution ($x_{2.5}, x_{97.5}$). Probability density functions for model parameters are given in Table 1.

RESULTS AND DISCUSSION

Distribution functions of the thyroid doses for 1 y, 10 y and 20 y age groups are shown in Fig.1. As can be seen from Fig.1, the probability density function represents a curve of lognormal distribution. Uncertainties factors in the term of geometric standard deviation were estimated to be 2.6 - 2.8. Such uncertainty according to the classification of [9], is considered as moderate, and the results of thyroid dose estimates within the model are characterized by an average degree of reliability.

Fig.1. Cumulative frequency distributions of thyroid doses for 1 y, 10 y and 20 y age groups
Ranking of model parameters according to their contribution in uncertainty of model prediction is shown on Fig. 2. As can be seen from Fig. 2, model is the most sensitive to the following parameters: initial interception factor of $^{131}$I by vegetation, feed-to-milk transfer factor, thyroid mass, and iodine ground deposition.

Fig. 2. Ranking of model parameters according to their contribution in uncertainty of model prediction

Results obtained could be used for the improving of thyroid cancer risk estimation for population exposed following the Chernobyl accident. Additionally, these results could be used as the basis for designing of stochastic model for the thyroid dose estimation.

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MONITORING OF CHROMOSOME ABERRATIONS AS BIOINDICATORS IN ASSESSMENT OF RADIATION/RADIONUCLIDE RISK FOR THE PEOPLE AND ECOLOGICAL HEALTH.

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ABSTRACT
The transparency in decision-making concerning problems of radioactive waste, weapon plutonium and accident radionuclide pollution demands an objective assessment of the radiation risk for people and ecological health.

Long-term cytogenetic monitoring of nuclear and chemical plant workers, local human populations of radioactive waste areas and radionuclide polluted territories has revealed that the level and spectrum of induced chromosome aberrations (structural damages of the cell genetic apparatus) in blood lymphocytes correlate with the type, dose and duration of exposure.

A high level of aberrations in the chromosomal spectrum was observed in many men after single (accidental) and multiple (cleanuping following Chernobyl explosion) external exposure to - or -/n°-radiations.

Increased levels of aberrations in the chromosomal spectrum and rare multiaberrant cells were observed after long-term/chronic mixed external/internal exposure to low doses of -/-radiation by radionuclides (inhabitants of Chernobyl polluted regions, Altai territories with radioactive fallout in result of nuclear explosions at the Semipalatinsk test-ground and radioactive waste areas near by Chelyabinsk and Tomsk atomic enterprises).

An increased level of aberrations in the chromatid spectrum was observed upon a long-term occupational contact with synthetic resins (polyvinylchloride, epoxy and phenolformaldehyde) and their monomers (workers of Vladimir resin plants).

There is very strong evidence that the yield of chromosome aberrations (Y) is related to the dose (D) by the equation:

\[ Y = A_0 + AD + BD^2 \]

Therefore the radiation/radionuclide risk (RD) will correspond to a absorbed dose and its aberrational/mutational consequences ("doubling dose" coefficient).

Increased levels of chromosome aberrations in the human body very often precede the development of several syndromes: chronic fatigue, secondary immune deficiency, early aging, oncology, reprodactive disfunction and etc.

Thus, induced chromosome aberrations in blood lymphocytes are objective bioindicators in assessment of the radiation/radionuclide risk for the people and ecological health.

The abovementioned confirms the necessity of creating a European network for ecological-genetic monitoring with "Internet" translation of information on radionuclide composition and chromosome aberration levels in people, inhabiting polluted areas.

The manking enters 3 rd millennium with a number of unsolved ecological problems. One of them is the lack of transparency in objective assessment of radiation /radionuclide risk for human health and ecosystems due to the accumulation in the 2nd half of the XX century of technogenic radioactive materials.
According to the UNSCEAR (1997), the main sources of radioactive contamination of the environment are:
nuclear tests in the air, underground and in the water carried out in the USA, USSR, GB, France, China, India (541 explosions in total);
production/reprocessing of nuclear fuel and weapon uranium and plutonium and a resulting accumulation of radioactive waste products (Fernald, Oak Ridge, Hanford etc. in the USA; Mayak-Chelyabinsk-40, SCK-Tomsk in the USSR and in GB, France, China);
nuclear power plants (NPP, about 500 reactors in total),
accidents at NPP and ships with nuclear power plants
The pollution of the environment, especially water basins, occurred in the recent past due to the use of imperfect technologies (L.Rikhvanov, 1997). The regional problems of contamination by artificial radionuclides have grown into global ones that aggravated in 1986 as a result of the catastrophe at the Chernobyl nuclear power plant: enormous masses of radioactive substances (over 50 million Ci) were released in the environment and dissipated. The radioactive cloud passed over Europe, Northern hemisphere and it was noted twice over the USA territory (S.Faller, H.Kuroda, 1990).
In the recent 10 years, the natural gaseous radionuclide $^{222}$Rn has increased because of the intensifications of ore mining and the expansion of construction works in the countries Scandinavia, Western Europe, etc.
The main risk comes from radioactive nuclides released into groundwater and transferred to potable water sources, or end up in food. (J-O.Liljenzin, J.Ridberg, 1996).
The influence of low-intensive radiation from dissipated radionuclides on people and ecological health is becoming a worrisome problem.
Considering the number and power of nuclear explosions, the number and types of nuclear reactors, the amount of radioactive waste products and emergency discharges of radionuclides, methods and models have been developed to determine local, regional and global annual doses that are usually estimated by the density of scattering of long-lived radionuclides $^{90}$Sr and $^{137}$Cs and are calculated for the population as collective effective doses (man/SV). The contribution of short-lived ($^{125}$I, $^{131}$I, etc.) and other radionuclides ($^{3}$H, $^{14}$C, $^{239}$Pu, $^{241}$Am, "hot α-particles" etc.) is usually not taken into account. Since in local, regional and global scales the impact of technogenic and natural radionuclides and medical isotopes is experienced by hundreds, thousands and millions of people, the assessment of radiation/radionuclide risk requires constant monitoring of the most informative and significant radiobiological effects in both individuals and local populations.
Of all radiobiological reactions of the human organism the chromosome aberrations in blood lymphocytes are most accurately quantifiable (WHO, 1973). Performing the immunoprotective functions, blood lymphocytes circulate over the whole body and are practically always exposed to ionizing radiation from radionuclides and chemical compounds penetrating inside the organism. Since 99,8% of T-lymphocytes are in the pre-DNA synthetic phase Go, the primary chromosome lesions are preserved in lymphocytes for a long time (months, years) and can be detected as aberrations under stimulation by PHA-antigen in vitro.
Long-term cytogenetic monitoring of nuclear and chemical plant workers, local human populations of radioactive waste areas and radionuclide polluted territories has revealed that the level and spectrum of induced chromosome aberrations in blood lymphocytes correlate with the type, dose and duration of exposure (I. Suskov, 1995).
A high level of aberrations in the chromosomal spectrum was observed in many people after single (accidental) and multiple ("cleanuopers" following Chernobyl explosion) external exposure to - or -/ n° -radiations (V. Shevchenco et. al., 1990 et al.).
Increased levels of aberrations in the chromosomal spectrum and rare multiaberrant cells were observed after long-term/chronic mixed external/internal exposure to low doses of ionizing radiation by radionuclides at inhabitants of Chernobyl polluted regions, Altai territories with radioactive fallout in result of nuclear explosions on the Semipalatinsk test-ground and radiative waste areas near by Chelyabinsk and Tomsk atomic enterprises (V. Shevchenko et al., 1995; N. Ilyinskikh et al., 1998).

An increased level of aberrations in the chromatid spectrum was observed upon a long-term occupational contact with synthetic resins (polyvinylchloride, epoxy and phenolformaldehyde) and their monomers at workers of Vladimir resin plants (I. Suskov, L. Sazonova, 1983).

Radiation genetics has strongly established that ionizing radiation have no minimal threshold doses: the hit of radiation quantum into unique genetic structure (DNA, chromosome) can cause a break and as result of it chromosome aberrations/gene mutations (N.V. Timofeev-Resovsky). The RBE (relative biological efficiency) of highly density-ionizing particles ($\alpha$, $\beta$, $\eta^0$) is 10-20 times higher than that of low density-ionizing $\gamma$-rays (IAEA, 1986). There is very strong evidence that the yield of chromosome aberrations ($Y$) is related to the dose ($D$) by the equation:

$$Y = Ao + aD + bD^2$$

where $Ao$ is spontaneous aberrations, $a$ is the linear coefficient and $b$ is squared coefficient of doses (Lea, 1963). However taking into account that the dose rate of external and incorporated irradiation from rare radionuclides is not high the quadratic component may be ignored.

Then the radiation/radionuclide risk $R(D)$ will correspond to:

1) absorbed dose

$$D(R) = \frac{\mu - \mu_0}{\mu_0^2 + \sqrt{2}b}$$

and 2) as its aberrational/mutational consequences: $\mu(D) = Y/Ao$, where $\mu(D)$ is the coefficient of approximation of radionuclide radiation dose absorbed by the organism to a dose doubling the frequency of spontaneous aberrations/mutations.

The "doubling dose" is a basic criterion of the hazard to the human somatic/genomic health and to the population gene pool.

 Quite satisfactory estimates have been obtained by the above described method for absorbed doses both in the liquidators of the Chernobyl accident (A. Semov et al., 1994), and in the inhabitants of territories contaminated by radionuclides as a result of accidents at the Chernobyl NPP (I. Suskov, 1991) and at the Siberian Chemical Plant in Tomsk (N. Ilyinskikh et al., 1997) and as a result of nuclear explosions on the Semipalatinsk test-ground (V. Shevchenko et al., 1995).

A result of prolonged influence of low-intensive radiation on the human body is accumulation cells with chromosome/genome aberrations, that very often precede the development of several syndromes: chronic fatigue, secondary immuno deficiency, early aging, oncology, reproductive disfunction and etc. (L. Baleva et al., 1997; V. Suskova et al., 1997).

Thus, induced chromosome aberrations in blood lymphocytes may serve a measure of ionizing radiation absorbed by the organism and are objective bioindicators in assessment of the radiation/radionuclide risk for the people and ecological health.

The abovementioned confirms the necessity of creating a European network for ecological-genetic monitoring with "Internet" translation of information on radionuclide composition and chromosome aberration levels in people, inhabiting polluted areas (I. Suskov et al., 1998).
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REGULARITIES OF CESIUM-137 CONTENT IN THE ORGANISMS OF INHABITANTS OF VYSOKAYA AND VORNOVKA SETTLEMENTS OF KORMA DISTRICT

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In 1997, an examination of population of Vornovka and Vysokaya villages of Korna district was carried out in order to reveal the connection between Cs-137 accumulation and professional activity, age and food pollution.

The radioactive pollution with Cs-137 of Vornovka and Vysokaya villages in 1996 constituted 5.2 Ci/km² and 10.9 Ci/km² respectively. Wide spread of maximum and minimum indices was observed (hundreds of times). The pollution of these villages with Sr-90 was practically identical and constituted 0.17 Ci/km², with Pu-238, 239, 240 - 0.0026 Ci/km² and 0.0049 Ci/km² respectively.

Food products were selected in spring-summer and autumn periods. The analysis of milk pollution in Vornovka and Vysokaya showed that the major part of milk in Vornovka - 77.8% - was polluted up to 50 Bq/l, however only 3.7% of milk was polluted over Republican Admissible Levels of radionuclide content in food and potable water (RAL) [1]. Whereas in Vysokaya only 59.2% of milk was polluted up to 50 Bq/l, and 27.3% had from 50 to 111 Bq/l. 13.5% of analysed milk was polluted over RAL, being thus this index 3.5 times as high as that in Vornovka. The correlation of milk pollution in Vornovka and Vysokaya is presented on figure 1. The pollution of potato in both villages was much lower than admissible levels and was from 5 to 30 Bq/kg. Meantime the fresh and potted food made of wild plants (sorrel, soft fruits etc.) were polluted over RAL in the majority of cases. Taking into account that their consumption in examined villages is quite considerable, they make a significant contribution into the dose of internal irradiation. The same about mushrooms. Though the pollution of mushrooms mainly does not exceed RAL, it is quite significant and almost always is near RAL. As the consumption of mushrooms in these settlements is considerable too, their contribution into the formation of internal irradiation dose may be significant too.

The examination of inhabitants of Vornovka and Vysokaya started in May. By the end of June, more than 400 persons were examined.
In June-beginning of August, it was carried out the repeated examination of schoolchildren who had returned after sanitation in Germany. One more examination of population of these villages was held in autumn.

The Cs-137 content in the organisms of inhabitants was measured with mobile measuring installation Fastscan/Canberra, provided from Germany. Fastscan is a counter of human radiation, a measuring system which determines spectra and is made for examining a big number of people.

Taking into account the profession and age of persons, the analysis of internal content of Cs-137 in organism showed that the results in various groups might considerably differ from the average for settlement. The machine operators had the highest level of content both in Vornovka and Vysokaya: 4.38 and 5.55 kBq respectively (figure 2). This is more than 2.5 times as high as the average values in settlements.

The schoolchildren had the lowest level of Cs-137. We must note that the internal Cs-137 accumulation varies much within separate groups. For example, the average value for schoolchildren in Vornovka constituted 0.94 kBq, and this was much lower than among all Vornovka inhabitants. While the minimum value was not even registered by the counter, the maximum one constituted 4.9 kBq. The same was characteristic for Vysokaya, only the maximum value for children under school age was 6.48 kBq. Among adults, the minimum Cs-137 accumulation was in teachers. In dependence of age group (figure 3), it is seen that the minimum Cs-137 content is in children under school age, then it grows and reaches maximum value in people of 40-60. The quantity of examined children with excess over the level of 4 kBq constituted in Vysokaya 6% and in Vornovka – 1%. The number of adults with excess over the level of 7 kBq was 7% in Vysokaya and 4% - in Vornovka.
The diagrams of relative Cs-137 content in organisms of schoolchildren of Vysokaya and Vornovka villages in dependence of age are adduced on figures 4 and 5.

Two conclusions follow from the analysis of diagrams. First: for the schoolchildren of both villages the autumnal increase of Cs-137 content is observed in all age groups. Second: there is a clear dependence of increase of Cs-137 content in the organisms on the age. Two maxima are observed: in schoolchildren of 6 and 13; the minimum of increase of Cs-137 content – in children of 8.

In Vornovka, the accumulation increased 2.76 times on the average; in Vysokaya – 3.32. The maxima: 17.5 in Vornovka and 9.24 in Vysokaya. In children who had been sanitized in summer, the increase of Cs-137 accumulation was on the average lower than in those who had not been sanitized. While the general growth of internal accumulation was observed, it was registered the decrease of Cs-137 content in organisms of certain schoolchildren. The percentage of such children was not high: 17.4% in Vornovka and 18.2% in Vysokaya. The level of decrease in the majority of cases did not exceed 10-20%. The comparative accumulation of Cs-137 in organisms of children who were sanitized in Germany in summer is shown on figure 6 as average values of groups in dependence of period: “spring-summer”, “after sanitation”, “autumn 1997”. The average value of pollution of schoolchildren of Vornovka thus constituted in three periods of 1997 0.67, 0.26, 1.75 kBq respectively, and that of Vysokaya – 1.14, 0.51, 2.14 kBq respectively. The accumulation in Vornovka decreased 2.6 times on the average; in Vysokaya – 2.2 times. Whereas in schoolchildren which had not been sanitized, the Cs-137 content in organism increased approximately 1.3 times. Probably, this is characteristic for summer period. All this shows the high efficiency of departure of children from polluted areas to “clean” ones for the summer.
CONCLUSIONS

1. The highest level of content in both settlements was registered in machine operators: more than 2.5 times as high as an average. The teachers turned out the less polluted among adults.

2. If we observe the Cs-137 content in organisms of Vornovka and Vysokaya inhabitants in dependence of age, it is minimum in children under school age, then it grows and reaches maximum in people of 40-60.

3. In schoolchildren who had not been sanitized, the growth of Cs-137 content in organism from spring to autumn was observed. There is a clear dependence of increase of Cs-137 content in organism on the age. Two maxima were observed: in schoolchildren of 6 and 13; the minimum increase of Cs-137 content was in children of 8.

4. The measurements in schoolchildren just after sanitation showed that the Cs-137 accumulation decreased in them more than two times. And in schoolchildren who had not been sanitized, the increase of Cs-137 content approximately 1.3 times was observed. This shows the high efficiency of departure of children from polluted areas to “clean” ones for the summer.

LITERATURE

1. Republican Admissible Levels of content of Cs-137 and Sr-90 radionuclides in food products and potable water (RAL-96).
IMPACT OF THE CHERNOBYL ACCIDENT ON THE RADIOACTIVE CONTAMINATION OF THE CROATIAN ENVIRONMENT

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ABSTRACT
This paper summarizes the data on the long term radioactive contamination caused by the Chernobyl accident. The special attention has been taken on $^{137}$Cs and $^{90}$Sr, as they have been recognized as the main contributors to the collective dose. After the period of intensive nuclear weapons tests conducted in the atmosphere, both $^{137}$Cs and $^{90}$Sr in the Croatian environment exponentially decreased. The Chernobyl accident caused a temporary increase of $^{137}$Cs fallout activities. However, as $^{90}$Sr is much less volatile than $^{137}$Cs, its levels in the Croatian environment were practically unaffected by the Chernobyl accident, the only exception being the cistern waters. Contrary to the public beliefs, Croatia has not been seriously affected by this accident. Consequently, the estimated risk on the Croatian population was found to be very small. This is consistent with the UNSCEAR assessment which shows that on a global scale, the total radiological impact of Chernobyl has been minor. From a radioecological point of view, the Chernobyl accident draws special attention to the vulnerability of some environmental compartments.

INTRODUCTION
The accident at Chernobyl nuclear power plant in Ukraine took place on April 26, 1986. Two explosions that occurred, the steam explosion followed by the explosion of hydrogen, expelled fission products as well as some material from fuel elements to the exterior. Because the graphite moderator ignited, the release acted as a prolonged elevated release. Consequently, volatile radioactive material accumulated in a cloud, reaching the height up to 7 km. It was estimated that about 100 Pbq of $^{137}$Cs was released and large parts of Europe became contaminated. In addition, changing meteorological conditions with wind of different directions at various altitudes and prolonged releases from a damaged reactor resulted in a very complex dispersion pattern over Europe. However, Croatia except from its very northern and very southern parts, was initially unaffected by the plumes of contaminated air (UNSCEAR 1988). Also, the late spring and early summer of 1986 in Croatia were rather dry, leading to relatively low direct radioactive contamination, which was especially true for the Adriatic region (Franic 1993). To estimate the impact of the Chernobyl accident on the radioactive contamination of the Croatian environment as well internal radiation doses to the Croatian population, investigations were especially focused on long lived radionuclides $^{137}$Cs and $^{90}$Sr. The samples collected involved fallout, air, soils, human foodstuffs and animal feed, bones, drinking water, sea and surface waters etc.

FALLOUT
Long-term investigations of $^{137}$Cs deposition in Croatia (figure 1) allow to conclude that in the year of Chernobyl accident total deposition of $^{137}$Cs exceeded the value recorded in middle 1960s, i.e., after the period of most intensive atmospheric nuclear tests. Deposition of 5.8 kBq m$^{-2}$ of $^{137}$Cs measured in 1986 was approximately 4000 times higher than in the previous year, and approximately 1300 times higher than in 1995.
In contrast to $^{137}$Cs, the Chernobyl accident did not cause any significant increase in $^{90}$Sr activities in most of the environmental samples in Croatia. Unlike the atmospheric testing of nuclear weapons, the radionuclides that originated from the Chernobyl accident were not released directly into the upper atmosphere. As the result of the release mechanism and the prevailing meteorological conditions at the time, the less volatile components of the Chernobyl debris (e.g., $^{90}$Sr) were deposited closer to the accident location than the more volatile constituents (i.e., radiocaesium). Thus, $^{90}$Sr was only in minor quantities subjected to the global dispersion processes, being deposited to the Earth's surface within a period of a few days to a few weeks after the accident. Figure 2 shows the long-term data on $^{90}$Sr deposition for the cities of Zagreb and Zadar. A minor $^{90}$Sr peak (191 Bq m$^{-2}$) has been measured only in Zagreb in May 1986. In August 1986 this value decreased to 1.8 and in November to only 0.1 Bq m$^{-2}$, leading to the total annual $^{90}$Sr deposition of approximately 193 Bq m$^{-2}$. As expected, the correlation between $^{90}$Sr deposition data in Zadar and Zagreb is very good, the coefficient of correlation being 0.95 for 36 observations. Besides $^{137}$Cs and $^{90}$Sr, in May 1986 were deposited significant amounts of $^{134}$Cs and $^{131}$I. In the Zagreb area, the measured activities were 31 31 kBq m$^{-2}$ for $^{134}$Cs and also 31 kBq m$^{-2}$ for $^{131}$I (Saric 1996). For radionuclides it takes approximately seven half-lives to decay to negligible levels. Therefore, after the Chernobyl accident, $^{131}$I (half-life 8.06 days) was present in the Croatian environment for approximately two months, while $^{134}$Cs (half-life 2.06 years) has been found in 1990s in some environmental samples, although in very small amounts.
Generally, as seen on figures 1 and 2, by the end of 1990s $^{137}$Cs and $^{90}$Sr activities have exponentially decreased to only few Bq m$^{-2}$. Therefore, direct risk from fallout radionuclides to Croatian population is minimal. However, in some environmental samples (mushrooms, cistern waters) can still be found some residual contamination (Franic 1992, Franic 1999). Also, owing to the metabolic behaviour of $^{137}$Cs and $^{90}$Sr, which is similar to that of potassium, and calcium respectively, the two radionuclides are transferred from soil to human food chain.

**FOOD CHAIN**

On the basis of data related to the contamination of most significant food components has been performed the assessment of the annual effective doses received from $^{137}$Cs and $^{90}$Sr ingestion by foods (Lokobauer 1998). Table 1 shows an estimated $^{137}$Cs and $^{90}$Sr yearly intake with foods and resulting effective dose for an adult member of Croatian population. The dose conversion factors used for dose assessment are $1.3 \times 10^{-8}$ Sv Bq$^{-1}$ for $^{137}$Cs and $2.8 \times 10^{-8}$ Sv Bq$^{-1}$ for $^{90}$Sr respectively (IAEA 1996).

<table>
<thead>
<tr>
<th>Year</th>
<th>$^{137}$Cs (Bq y$^{-1}$)</th>
<th>$^{90}$Sr (Bq y$^{-1}$)</th>
<th>Effective dose (μSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>17857</td>
<td>3583</td>
<td>333</td>
</tr>
<tr>
<td>1985</td>
<td>36</td>
<td>71</td>
<td>3</td>
</tr>
<tr>
<td>1986</td>
<td>7786</td>
<td>182</td>
<td>106</td>
</tr>
<tr>
<td>1995</td>
<td>88</td>
<td>78</td>
<td>3</td>
</tr>
</tbody>
</table>

Special attention was paid to milk activities, as milk is a sensitive indicator for the presence of fission-derived radioactive contamination in the environment. The dose due to radiocaesium ingestion by milk consumption was estimated to be 205 manSv in 1986 (Franic 1998) and less than 1 manSv in 1998.
CONCLUDING REMARKS
Although the public perception in the Republic of Croatia is different, the levels of radiation exposure due to the Chernobyl accident did not represent a major health concern. This complies with the UNSCEAR assessment which shows that on a global scale, the total radiological impact of Chernobyl has been minor in technical terms. This amount is about 5 percent of the global collective dose delivered by natural sources each year. However, in case of a future major nuclear accident a lot of unnecessary human suffering could be avoided, if the present poor information level of the public was improved significantly. As more than decade after the Chernobyl accident certain environmental samples still contain some residual contamination by fission radionuclides, from a radioecological point of view the Chernobyl accident draws special attention to the vulnerability of some environmental compartments.

REFERENCES
ABSTRACT

The production of electrical energy from fossil fuel, among other pollutants, gives rise to emission of radioactivity. After incineration of coal, the initial radioactivity becomes 7-10 times more concentrated. Consequently, the storage of large quantities of ash and slag may pose significant environmental risk. Investigations of natural radioactivity, particularly radium and uranium have already been performed on selected locations along the Croatian coast, as a part of an extensive monitoring program of the Croatian environment, conducted by the Radiation Protection Unit, Institute for Medical Research and Occupational Health, Zagreb. This paper deals with increased levels of natural radioactivity in the bay at the Croatian coast, due to continuous accumulation of slag and ash originated from regular operation of the power plant. The coal fired power plant is situated about 5 km from the seaside. Previous investigations of used coal resulting slag, showed increased activity concentrations of natural radioactivity. In order to assess the risk for the employees in the plant and inhabitants of the area, were performed analyses of the radioactivity levels at the slag and ash deposits as well as dosimetric measurements. In order to assess the sensitivity of the bay to the radioactive pollution, natural radioactivity concentrations were also studied in the zone between the plant and the seaside as well as in sea water.

INTRODUCTION

The fossil fuel power stations are one of the sources of the technologically enhanced natural radioactivity (TENR). After incineration of coal, the initial radioactivity becomes 7-10 times more concentrated. The presence of radioactivity in chemical industry and in energy production due to TENR can exceed several times than that background radiation (UNSCEAR 1993). Consequently, the storage of large quantities of ash and slag may pose significant environmental risk. It is known that the most important burden to the environment from the fossil fuel power stations is atmospheric pollution, site contamination due to storage of large quantities of ash and slag containing increased radioactivity levels, and contamination of the immediate human environment (Marovic et al. 1989). Direct radiation exposure from increased deposited radioactivity results from waste piles containing ash of higher radioactivity than normal. Several coal mines in Croatia have more or less elevated concentrations of natural radioactivity. The presence of uranium varies from mine to mine and even from one coal-layer to another in the same mine. The coal used for combustion described in this paper originates from a coal mine which in addition to higher levels of natural radioactivity (uranium), has an elevated concentration of sulphur, up to 10%. The uranium content in coal for many years varied around 25 ppm (Marovic et al. 1997, Marovic et al. 1998). The paper deals with increased levels of radioactivity in the bay at the Croatian coast of the Adriatic sea, which is due its geographic location exposed to pollution including the radioactivity. Power plant pile is situated close to the power plant site, in the western littoral area of the Istrizian peninsula, about 5 km from the seaside, and 10 km north-west from the more populated urban area in the continental part of the region. Environmental preservation
and human health protection measures, performed on the site so far, have been directed basically to covering of contaminated material by soil and clay material. However, this study is a part of risk assessment analysis targeted to study the possible movement of radioactivity to the sea water.

MATERIAL AND METHODS
Investigations of radioactive contamination were based on measurements performed in the field and in the laboratory. In situ gammaspectrometrical measurements were carried out using HPGe Ortec detector (resolution 1.74 KeV on 1.33 MeV $^{60}$Co, relative efficiency 21.6%), and included several deposit sites in the plant and its vicinity. Measuring time was 1000 sec. All liquid samples were radiochemically separated, after which $^{226}$Ra was determined by alpha spectrometric measurements using silicon charged particle Si(Li) surface barrier detector. The counting time for each measurement was 80,000 sec.

RESULTS AND DISCUSSION
In situ gammaspectrometrical measurements involved several measuring sites at the operating ash and slag pile deposit, at the pile covered by soil and one location at the seaside. Measurements showed the presence of natural radionuclides of uranium and thorium decay series as well as $^{40}$K. Corresponding contribution of measured radionuclides to the absorbed dose rate was calculated for each location (Beek et al. 1972). Figure 1 shows contributions of radionuclides of uranium and thorium decay series and $^{40}$K to the absorbed dose rate at 5 selected locations on the operating part of pile. The results of measurement indicated a great dispersion of the obtained absorbed dose rates.

Figure 1.Contribution of radionuclides of uranium and thorium series and $^{40}$K to the absorbed dose rate

Figure 2 shows contributions of radionuclides of uranium and thorium decay series, $^{40}$K and $^{137}$Cs to the absorbed dose rate at 4 locations on the non-operating part of pile, covered by soil. Location 5 is situated at the seaside. The presence of $^{137}$Cs on all locations can be attributed to the vegetation. The difference between the locations on pile and the seaside is noticeable.
The performed statistical analysis of the difference in contributions to the total absorbed dose rate from operating pile and part of pile that is covered by soil showed statistically significant difference. Contribution of radionuclides from uranium decay series is greater on operating part of the pile (at level of \( P(t) < 0.01 \)) while, for the contribution of radionuclides from thorium decay series statistically significant difference was not determined (\( P(t) > 0.05 \)). This can be attributed to the fact that used coal had elevated radioactivity concentrations of radionuclides from the uranium decay series. As expected, in the case of \( ^{40}K \) the same statistical analysis has shown that higher contribution to the absorbed dose comes from the covered part of the pile, with statistically significant difference at level of \( P(t) < 0.01 \). This can be accounted to the vegetation on covered part of the pile as well as lack of potassium on uncovered part.

In last few years in the samples of sea water in the bay mean \(^{226}\text{Ra}\) activity concentration was \( 13.2 \times 10^1 \text{Bq m}^{-3} \) (maximum was \( 26.4 \times 6.6 \text{Bq m}^{-3} \) and minimum \( 5.2 \times 0.9 \text{Bq m}^{-3} \)). This value is up to 3.5 times higher than that in the Mediterranean Sea (\( 3.7 \text{Bq m}^{-3} \)), as well as in the open Adriatic sea far from the plant deposit bay (UNEP 1991). It should be noted that the pile site is provided by drainage system which considerably lowers erosional, derasional and proluvial processes, whilst retention pool - situated between the plant and the coastline - diminishes sedimentation of eroded terrestrial material (including stored slag and ash) into adjacent Plomin bay.

Detailed site characterization and risk assessment will show which clean-up method would be preferable for safely insulation of contaminated slag and ash and prevention of radioactivity transfer to the sea water.

**CONCLUSION**

On the basis of our study and the obtained data it can be concluded that the investigated power plant and its deposit site present no significant risk to the inhabitants and the environment of the region, although the problem of environmental contamination from TENR cannot be neglected. The pile site drainage system efficiently diminishes the transfer of radioactivity into sea, as in the sea-water samples from nearby bay elevated radioactivity levels were not detected. The results of the measurements also confirm that the ash and slag deposit site of both the protected and still operating part of the deposit site are well monitored.
and involve all the necessary protective measures. All obtained data can be used as a valuable database for future estimations and modeling of the impact of radioactive pollution to the marine environment and developmental prospects of the region.

LITERATURE


THE BEHAVIOUR OF THE RADIONUCLIDES $^{137}$Cs AND $^{90}$Sr IN THE RESERVOIR ECOSYSTEM OF THE FAR ZONE INFLUENCE OF THE CHERNOBYL APS ACCIDENT

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The watercollections of the Dnieper, Soj, Pripjat and partially Njoman rivers with their tributaries were exposed to the essential radioactivity influence. The common area of radioactivity contamination by the radionuclides $^{137}$Cs and $^{90}$Sr of the Belarus’ territory is than more 40 000 km$^2$, with the density of contamination larger 40 Ku/km$^2$ - 2 480 km$^2$; 15-40 Ku/km$^2$ - 4 600 km$^2$; with density 5-15 Ku/km$^2$ - 10 260 km$^2$, and with density of contamination 1-5 Ku/km$^2$ - 22 700 km$^2$.

The different forms of radionuclides quickly to include themselves into the exchange processes of water - aquatic inhabitants - bottom sediments system. Similar processes occur particularly quickly in the vegetation period. The aquatic inhabitants particularly aquatic vegetation, as known, have a high capacity for radionuclide accumulation. The partial burial of radionuclides in the bottom sediments takes place when aquatic inhabitants die. The radionuclides of the surface layer of bottom sediments to be included in the repeated migration cycles including biological cycle during disruptions as they are stirred by the wind, water and the influence of spring floods and heavy rains.

The object under investigation is the relatively small river-bed type reservoir near v.Malinovka Cherikov district Mogilev area. It has a water surface area on the SWL mark of 0,27 km$^2$, the water collection area of 23,8 km$^2$, the water volume on the SWL mark of 373 000 m$^3$. The reservoir is 1,8 km long and 0,36 km wide. Together with water its water-collection area the water of the Senna river (tributary of the Soj river) provides of the water nutrition for the reservoir. The reservoir is relatively new and was put use into 1982.

The aim of investigation is the study of behaviour of $^{137}$Cs, $^{90}$Sr in the artificial reservoir Malinovka ecosystem placed at 250 km distance from ChAPS in the alienation zone. The investigations were carried out in 1990-1998, mostly, in spring, summer and autumn. In the process of long-term radioecological monitoring suches components of water ecosystems as filtered water, water suspensions, bottom sediments and water vegetation were investigated.

The content of principal radionuclides - $^{137}$Cs, $^{90}$Sr in water ecosystem components was determined in the laboratory conditions with use of standard methods of semiconductor gamma-spectrometry, beta-radiometry and radiochemistry with gamma- and beta-termination.

The need for radioecological monitoring is explained by the danger of radioactive contaminated components of the ecosystem of reservoir. A residential area is 5 km away from the reservoir. This is the danger because the reservoir ecosystem despite prohibition is being used of local rural population for fishing purposes and as watering-place for cattle.

The reservoir near v.Malinovka underwent considerable pollution as a result of radionuclides aerosol precipitation and as a result of secondary contamination (site of decontamination of automobiles from the nearest accident zone was established on its shore). As a consequence, the water collection areas were polluted with a density of up to 200 000 Bq/kg for $^{137}$Cs and up to 1 120 Bq/kg for $^{90}$Sr in 1990 -1998.

If the activity of filtered water of the Malinovka reservoir for $^{137}$Cs in period 1990-1998 didn’t exceed the Republic’s permitted level (RPL) - 18,5 Bq/l, the excess was registered for $^{90}$Sr -
0.44 Bq/l in May 1990 (\(^{90}\)Sr RPL - 0.37 Bq/l). In the next years the values of specific activities of water for \(^{90}\)Sr were in interval 0.12 - 0.33 Bq/l. There are data of \(^{90}\)Sr, \(^{137}\)Cs content in water suspensions(fig.1b), soils of water-collection areas and bottom sediments(fig.1c).

Together with the radioecological state water appraisal with reference to RPL we used the scale of radioecological assessment elaborated by Ukrainian hydrobiologists in 1993 \(^{2}\). The water in the Malinovka reservoir is classified thus: contamination by \(^{137}\)Cs is from slightly contaminated to moderately contaminated (II-III levels), quality is classified from satisfactory cleanliness (class 3) to contaminated (class 4), the category of the quality of water is classified from feebly contaminated (category 3b) to the moderately contaminated (category 4a).

Thus according to this classification the range of feebly contaminated water on \(^{137}\)Cs is from 0.004 - 0.185 Bq/l, and the moderately contaminated - 0.19 - 5.6 Bq/l. The specific activity of \(^{137}\)Cs of reservoir water was 0.05 - 0.77 Bq/l during the research period.

The reservoir water on \(^{90}\)Sr has III level of radioactivity contamination (moderately contaminated), the class of quality is 4 (contaminated), the category of quality is 4a (moderately contaminated) and is found in a range of activities from 0.12 to 0.44 Bq/l.

Ukrainian radioecologists estimate the levels of limit contaminated water on \(^{90}\)Sr - more than 14.8 Bq/l and on \(^{137}\)Cs - more than 555 Bq/l \(^{3}\). Such high values were observed very seldom for the aquatic areas of Belarus even in the first months after the ChAPS disaster.

The composition of dominating water vegetations was small and consist only of seven species of macrophytes and the inferior algae from families of Cladophora and Oedogonium. Amongst the macrophytes in the reservoir ecosystem the next species dominated: \textit{Elodea canadensis} Rich., \textit{Typha latifolia} L., \textit{Potamogeton natans} L. The least predominant were the metted \textit{Oenanthe aquatica} L., \textit{Glyceria aquatica} Wahlb., \textit{Alisma plantago aquatica} L., \textit{Equisetum fluviatile} L. Such species as \textit{Elodea canadensis} L., \textit{Typha latifolia} L. and the inferior algae were constantly present from 1990-1998 and they have the large biomass and enough great areas of overgrown.

The next results were obtained too:

- a constant tendency in a fall of activities \(^{137}\)Cs, \(^{90}\)Sr of water, suspensions, bottom sediments (fig.1a,1b,1c) in the period 1990-1998 has not been observed;
- the rise in activities of \(^{90}\)Sr in the reservoir water over the amount of \(^{137}\)Cs equates Malinovka reservoir with the some reservoirs of near ChAPS accident zone;
- the reservoir ecosystem is similar to the cooler-reservoirs of APS, in particularly, to the Belojarskoje reservoir, Ural’s region of Russia on the portion contents of the radionuclides in the bottom sediments, aquatic vegetation from the common radioactivity of the ecosystem reservoir Malinovka components;
- a constant fall in radioactive contamination of aquatic vegetation (fig.1d) has not occured over the years which is indicated by the processes of the radionuclides inside recycling and the all new radionuclides receivings from water-collection areas from the reservoir ecosystems;
- the contribution of the aquatic vegetation in the summary radioactivity proved to be insignificant and not exceed 0,023 % on \(^{137}\)Cs and 0,014 % on \(^{90}\)Sr on cause of the relatively youth of reservoir (small biomass and unimportant area of aquatic vegetation overgrown);
- the main contribution in the summary radioactivity of the reservoir ecosystems components brings in the bottom deposits - 94.6-99.9 % on \(^{137}\)Cs and 57 - 99.5 % on \(^{90}\)Sr; the part of water sediments is 0.01 - 0.61 % \(^{137}\)Cs and 0.03 - 8.08 % \(^{90}\)Sr; and part of strictly filtered water is 0.013 - 4.81 % \(^{137}\)Cs and 0.5 - 41.37 % \(^{90}\)Sr.
Risk Analysis: Facing the New Millennium

![Graph a)](attachment:image1.png)

![Graph b)](attachment:image2.png)
Fig. 1. The dynamics of the Radioecological situation for the Malinovka Reservoir, the far zone of influence of the Chernobyl APS Accident:

a) filtered water of reservoir;
b) water suspensions;
c) bottom sediments;
d) water vegetation.

MODELING THE CESIUM-137 AIR TRANSFER FROM POLLUTED TERRITORIES

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Since September 1986, the radioactivity of near-earth atmosphere on Belarus territory was determined mainly by the processes of secondary resuspension and transfer of radioactive particles precipitated as a result of Chernobyl APS accident. More significant concentrations of Cesium-137 in the air - as compared with pre-accident ones - are conditioned in adjacent zone by "local" dust and dust transfer from zone of high pollution and, at large distances, by wind lifting of radioactive dust from surface in given area.

Considerable part of Belarus is polluted with Cesium-137, therefore it is to be expected that both "local" dust and remote transfer can make contribution into the air pollution. In the modeling of near-earth atmosphere pollution with Cs-137, its concentration has been calculated as the sum of two components:

\[ \psi = \psi_d + \psi_m \]  

where \( \psi_d \) and \( \psi_m \) - concentrations of admixture from remote and local dust sources respectively.

To the development of model notions of round area sources of dust with Gauss statistical model of admixture distribution in atmosphere as a basis, the polluted territories of European part of CIS with pollution density over 1 Ci/km² for Cs-137 have been presented by 31 round area sources covering the principal pollution "spots". The differences of wind tearing for arable and non-arable lands have been taken into account in the model. The average coefficient of wind tearing has been calculated for the area of each source with regard to the share of arable lands and the content in upper one-centimeter layer of soil.

Thus the coefficient of wind tearing for "k" source can be calculated with formula:

\[ \alpha_k = [6.5 \ p_k + (4.2+9.8) (1- p_k)] \times 10^{-12}, \ \text{c}^{-1} \]  

where \( p_k \) - share of arable lands of "k" source.

Cs-137 concentration in any point is determined as superposition of contribution of separate sources:

\[ \psi = \sum_{k=1}^{31} \sqrt{2/\pi} \ \frac{\alpha_k \ m_j \ n_j}{\pi \ x_k^2} \ \sum_{j=1}^{6} \omega_j \ \int_{-\infty}^{\infty} \exp \left[ -\left( \frac{x_j \ x_k}{\sigma_{j,k}} \right)^2 \right] \ \frac{\ n_j}{\sigma_{j,k}} \ \exp \left[ -\Lambda (x_j - x_k) \right] \]  

where \( k \) - source index; \( j \) - index of category of atmosphere stability; \( m \) - index of calculation point; \( \alpha_k \ \text{c}^{-1} \) - coefficient of wind tearing; \( n \) - number of sectors of wind-rose; \( \eta_{m,k} \) - frequency of wind blowing in given direction; \( x_k^m \) - distance from the centre of "k" source to "m" calculation point; \( \omega_j \) - repetition in "j" category in observed time; \( \bar{u} \) - average wind speed.
in "j" weather category; \( v_g \) - speed of "dry" sedimentation of admixture; \( \sigma_{z,j,k} = \sigma_{z,j,k} (x^m_k - x'_k) \) - standard deviation of admixture in "z" direction; \( x' \) - current coordinate of source; \( \Lambda \) - constant of washing-out by precipitations; \( R_k \) - source radius.

In calculations made by formula (3), the speed of "dry" sedimentation of radionuclides has been taken the same as for global fallouts \( v_g = 0.016 \) m/s [1]. The coefficient of washing-out by precipitations has been taken as \( 2.6 \times 10^{-5} \) c' equal to that for aerosol fallouts of APS [2]. The coefficients \( \sigma_g \) have been calculated by Smith-Hosker formula for \( z_0 = 100 \) cm [3]. The frequency of wind for each azimuth direction from 1-8 has been equal to 0.11; 0.08; 0.11; 0.15; 0.11; 0.13; 0.18; 0.13 respectively.

The contribution of local sources into the concentration can be presented as:

\[
\psi_m = \frac{1}{v_a} \alpha A, \quad (4)
\]

where \( \alpha A \) - power of dust release; \( 1/v_a \) - coefficient of proportionality.

By the data of [1], for middle belt of CIS, \( v_a = 0.02 \) m/s. In order to make systematical calculations of near-earth atmosphere pollution with Cs-137, the Belarus territory has been covered by the grid with 50X50 km cells. The scheme with grid over Belarus map is adduced on figure 1. The results of calculations of annual near-earth concentrations of Cs-137 in knots of coordinate grid are adduced on table 1.

Table 1.: Annual near-earth concentrations of Cs-137 on Belarus territory on knots of coordinate grid

<table>
<thead>
<tr>
<th>Knot #</th>
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<th>( \psi_d ), mcBq/m³</th>
<th>( \psi_s ), mcBq/m³</th>
<th>Knot #</th>
<th>( \psi_m ), mcBq/m³</th>
<th>( \psi_d ), mcBq/m³</th>
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<td>1.3</td>
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<td>60</td>
<td>130.0</td>
<td>35.0</td>
<td>170.0</td>
</tr>
</tbody>
</table>
The analysis of results shows that the annual near-earth concentrations of Cs-137 on Belarus territory vary in dependence of calculation point by more than two degrees: from 1 mcBq/m$^3$ to 400 mcBq/m$^3$.

On the areas situated between "Mogilev", "Vilia-Volozhin" and "south", prevails the contribution of Cs-137 brought from remote sources. The calculations show that the contribution of "remote" component is maximum on relatively clean territories adjacent to the principal pollution spots.

The summary near-earth concentration of Cesium-137 in the west, north-west and north of Belarus constitutes (1+2) mcBq/m$^3$, on the east border in dependence of calculation point - 5 mcBq/m$^3$ + 140 mcBq/m$^3$, on south - from 400 mcBq/m$^3$ + 2 mcBq/m$^3$ by moving west.

The calculations permit to make conclusions about the contributions of different "spots" of pollution into the formation of atmosphere pollution. The results of calculations of contributions of different spots into the summary component of annual near-earth concentration for a number of Belarus cities are given in table 2. The contribution of local wind transfer (local component) for Minsk, Mozyr and Mogilev is over 50%, and only for Gomel it constitutes 39%. The contribution of remote component for Gomel is completely conditioned by air transfer of Cs-137 from Mogilev spot of pollution: 58%, whereas the south spot influences much more the atmosphere pollution in area of Mozyr.

The comparison of calculated and observed annual near-earth concentrations of Cs-137 for Mozyr, Mogilev, Minsk and Gomel is adduced in table 3. On the whole, the satisfactory concordance of calculated and experimental data is observed. For example, the calculated concentration of Cs-137 in the air for Gomel has constituted 67 mcBq/m$^3$, including for account of remote transfer - 26 mcBq/m$^3$, and the observed value - 65 mcBq/m$^3$. Difference in calculated and experimental data for Minsk appears, probably, because the coefficient of wind tearing in the conditions of big city is other.
Table 2: Contributions of pollution spots into the formation of Cs-137 concentration

<table>
<thead>
<tr>
<th>Groups of sources</th>
<th>Contribution into the concentration, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Contribution of local wind transfer</td>
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<td>Resuspension</td>
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<td>Regional wind transfer</td>
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<td>South spot</td>
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</tr>
<tr>
<td>West spot</td>
<td>0.1</td>
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<tr>
<td>Mogilev spot</td>
<td>58.2</td>
</tr>
<tr>
<td>Other sources</td>
<td>0.1</td>
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</table>

Table 3: Comparison of calculated and observed annual near-earth concentrations of Cs-137

<table>
<thead>
<tr>
<th>Settlement</th>
<th>Cs-137 concentration, mBq/m²</th>
<th>Local dust release</th>
<th>Remote transfer</th>
<th>Sum</th>
<th>Observations, sum</th>
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LITERATURE
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<td>9</td>
<td>10</td>
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</table>

The analysis of results showed that the ambient radionuclide concentrations of Cs-137 in the soil are not significantly different from the background values. This indicates that the contamination is not due to a recent input of cesium-137. The concentrations are within the range of natural background levels. The results suggest that the source of contamination is likely to be a historical event that occurred in the past and has not significantly impacted the current soil conditions.

The calculations presented in Table 2 allow us to make conclusions about the contributions of different sources to the formation of atmospheric pollution. The results of calculations indicate that the contributions of different sources to the mean concentration of cesium-137 in the air are as follows: nuclear testing, 10%; fuel reprocessing, 20%; and local sources, 70%. The contributions of local sources are estimated to be the most significant, indicating that they are the primary source of contamination in the area.
TRACK 5

SESSION 2

RADIATION /NON-RADIATION – SOMATIC CONSEQUENCES
MUTAGENIC CONSEQUENCES OF RADIATING POLLUTION OF SIBERIA

N.N. Ilinskikh, I.N. Ilinskikh, E.N. Ilinskikh, B.V. Smirnov
Siberian medical University
634050, Tomsk 50, a/ya 808
Russia.

More than twenty thousand inhabitants of Siberia and the Urals, subjected to a radiating effect as a result of explosions on the Semipalatinsk nuclear range and after failures at the enterprises making elements of nuclear weapons were investigated by genetic methods (chromosomal, micronuclear and DNA-repair tests). It has been established, that the effective equivalent dose of radiation much exceeded the level which the person can receive for life from natural sources of radiation in more than 50% of the cases. In some people this dose was much higher 1 Gy. A high level of cells with cytogenetic breaks were predominantly observed in the people born in periods when there were radiating failures or "dirty" nuclear tests on Semipalatinsk nuclear range. The authors assume, that the long preservation in the body of the person of genetic instability is stipulated by occurrence of genetically defective cells in the person in the prenatal period of life. It has been established, that in the long term effects of radiation, the following changes are observed in the people: the number erythrocytes with micronuclei, T-lymphocytes with micronuclei and chromosomal breaks is increased, thus the activity excessive DNA-repair is reduced. Ring and dicentric chromosomes prevailed among other types of cytogenetic breaks in lymphocytes. Genetic instability was accompanied by essential hematologic and immunologic changes. Reduced ability of lymphoid of cells to produce interferon and DNA-repair was observe in the people with high cytogenetic instability. It is established, that the long term radiating pollution of a district causes a change of parity in boys and girls among new-borns, increasing the number of girls. The people at the age of 80-90 years are present among the inhabitants of the Altai Territory living near Semipalatinsk nuclear range. It is established, that they have a determined genotype on a system HLA. The cells of the people with this genotype have increased mutagenic stability to radiation in a dose 1 Gy. The cytogenetic instability is observed also among dove, mice, some kinds of fish and molluscs living in districts located near Semipalatinsk nuclear range and Siberian of chemical combine (Tomsk-7).
BIOLOGICAL EFFECTS OF LOW-DOSE CHRONIC IRRADIATION IN SOMATIC CELLS OF SMALL MAMMALS

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The aim of the investigation was to study a possible mutagenic activity of low dose chronic ionizing irradiation. The frequencies of cytogenetic damages in somatic cells of bank voles (Clethrionomys glareolus, Schreber) from natural populations living in the areas with different ground deposition due to the Chernobyl accident and the levels of radiation loads have been studied. The direct relationship between the frequencies of injuries (chromosome aberrations and micronuclei in bone marrow and peripheral blood cells) and the levels of incorporated radionuclide concentration (4–145410 Bq/kg, $^{134+137}$Cs), absorbed dose rates (2–730 μGy) was demonstrated. This proves the genetic efficiency of very low doses of chronic irradiation for mammals.

INTRODUCTION.
The problem of biological efficiency of low-dose chronic irradiation seems to be the most important task for risk assessment. Reality of biological effects of extremely low doses of irradiation as well as forms of dose-response relationships remain unclear.

We have carried out an analysis of dynamics of cytogenetic injury frequencies in somatic cells of mouse-like animals (bank voles) living in 1986–1996 in areas of the Republic of Belarus at low intensity irradiation due to the Chernobyl fallout, and that of radiation loads. Since the whole Belarus area is contaminated with the Chernobyl fallout [1], detection of actually “clean” control in studying biological effects of an increased radiation background for animals and human is impossible. In this case the correct approach is 1) to study territories representing the density gradient of radiocontamination and, correspondingly, living organisms representing the gradient of absorbed doses; 2) to analyse the dose–effect relationship.

MATERIALS AND METHODS.
Bank voles were collected from four trapping sites differing in radionuclide contamination density of soil (Table 1). The data on $^{137}$Cs, $^{134}$Cs, $^{106}$Ru, $^{144}$Ce contamination were obtained in the year of accident (1986). The concentrations of $^{90}$Sr and transuranic elements in samples of soils were measured in 1996.

<table>
<thead>
<tr>
<th>Site</th>
<th>$^{137}$Cs (kBq/m²)</th>
<th>$^{134}$Cs (kBq/m²)</th>
<th>$^{106}$Ru (kBq/m²)</th>
<th>$^{144}$Ce (kBq/m²)</th>
<th>$^{90}$Sr (kBq/m²)</th>
<th>$^{239,240}$Pu (kBq/m²)</th>
<th>$^{238}$Pu (kBq/m²)</th>
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<td>18</td>
<td>9</td>
<td>12</td>
<td>–</td>
<td>–</td>
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<td>440</td>
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<td>3050</td>
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<td>2.35</td>
<td>1.17</td>
<td>86.67</td>
<td>3.21</td>
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</table>

* In brackets – distance (km) from the Chernobyl Nuclear Power Plant

Mutability of bank vole somatic cells was studied by the metaphase analysis of the chromosome aberration frequency in bone marrow and the micronucleus test in erythrocytes of both bone marrow and peripheral blood of animals. The detailed description of sites and the...
radiometric analysis of soil samples and animals as well as the methods of cytogenetic analysis are properly described in previous publications [2–5]. Conventional formulae and coefficients [6] were used to calculate the total whole-body absorbed dose rates related with the chronic exposure to γ-rays and internal exposure to incorporated $^{134+137}$Cs. In 1996 the contribution of incorporated $^{90}$Sr and transuranic radionuclides to the whole-body dose rates was also taken into consideration.

**RESULTS AND DISCUSSION.**

Increased frequencies of structural and genomic mutations in somatic cells were recorded in bank voles from chronically irradiated populations at the sites 1–4 in 1986–1996 in comparison with the pre-Chernobyl data [2, 4, 5]. Regression analysis of the relationship between individual frequencies of cytogenetic injuries and individual dose loads was carried out to reveal the possible existence of the relationship between environmental radioactivity and recorded damages (Table 2).

Table 2: Relationships between the chromosome aberration frequencies in bone marrow cells and radiation loads in bank voles (approximation by polynomial of 2nd degree)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of animals</th>
<th>Radionuclide concentration</th>
<th>Absorbed dose rate</th>
<th>Absorbed dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range of concentration, Bq/kg</td>
<td>$R^2$</td>
<td>Range of dose rate, μGy/day</td>
</tr>
<tr>
<td>1986</td>
<td>42</td>
<td>38 – 24844</td>
<td>0.13*</td>
<td>6 – 670</td>
</tr>
<tr>
<td>1987</td>
<td>35–36</td>
<td>3959–145410</td>
<td>0.17*</td>
<td>205 – 615</td>
</tr>
<tr>
<td>1988</td>
<td>38–43</td>
<td>58 – 385810</td>
<td>0.07</td>
<td>3 – 730</td>
</tr>
<tr>
<td>1991</td>
<td>32–41</td>
<td>5 – 20736</td>
<td>0.48**</td>
<td>3 – 132</td>
</tr>
<tr>
<td>1996</td>
<td>37</td>
<td>4 – 2911</td>
<td>0.27**</td>
<td>2 – 46</td>
</tr>
</tbody>
</table>

$R^2$ – coefficient of determination; * – $P<0.05$  ** – $P<0.01$

Animals inhabited sites 1–4 were coalesced in one sample within every year of investigations, representing the gradient for the level of radiation load. Statistically significant relationship between the chromosome aberration frequencies and the levels of incorporated radionuclide concentration, absorbed dose rate, and absorbed dose in these groups of animals was revealed (Table 2). A substantial dependency between the cytogenetic injury frequencies and radiation loads was also detected in many investigated populations taken separately. The form of the relationship between the cytogenetic effects and radiation load could be described in some cases by a linear equation (with significant coefficients of determination). However, all the data were better approximated by a polynomial function of 2nd degree (Table 2).

Table 3: Population means of $^{134,137}$Cs content and absorbed dose rate in bank vole in 1996

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of animals</th>
<th>Concentration of incorporated caesium isotopes, Bq/kg</th>
<th>Absorbed dose rate (μGy/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>External γ-irradiation</td>
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<td>30</td>
<td>6</td>
<td>2.78</td>
</tr>
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<td>2</td>
<td>40</td>
<td>25</td>
<td>2.32</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>162</td>
<td>6.25</td>
</tr>
<tr>
<td>4</td>
<td>49</td>
<td>1182</td>
<td>37.75</td>
</tr>
</tbody>
</table>

Genetic efficiency of extremely low doses absorbed by the investigated animals at the sites 1–4 in 1996 was verified by micronucleus test in erythrocytes of bone marrow and peripheral blood. Concentrations of incorporated caesium isotopes and, correspondingly, absorbed dose rates in voles included into micronucleus assay are presented in Table 3. The exposure dose
rate in 1996 exceeded the background levels and made up 12, 10, 27 and 163 µR/h at the sites 1–4, respectively.

Population mean frequencies of micronucleated polychromatic erythrocytes (MN-PCE) of bone marrow and micronucleated normochromatic erythrocytes (MN-NCE) in peripheral blood for all regions examined are shown in Table 4.

Table 4: Population mean frequencies of micronucleated erythrocytes in bank vole

<table>
<thead>
<tr>
<th>Site</th>
<th>Bone marrow</th>
<th>Peripheral blood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of animals / cells</td>
<td>MN-PCE, %</td>
</tr>
<tr>
<td>1</td>
<td>32 / 160000</td>
<td>2.12</td>
</tr>
<tr>
<td>2</td>
<td>20 / 100000</td>
<td>2.25</td>
</tr>
<tr>
<td>3</td>
<td>18 / 90000</td>
<td>1.50</td>
</tr>
<tr>
<td>4</td>
<td>26 / 130000</td>
<td>2.73</td>
</tr>
</tbody>
</table>

A regression analysis allowed to detect the direct relationship between the individual frequencies of MN-PCE and the individual concentrations of incorporated radionuclides and individual rates of absorbed dose (Figure, the upper line) from internal β-, γ-irradiation by caesium isotopes in bank voles from sites 1–4 pooled in one sample. The same data were obtained for MN-PCE (Figure, the bottom line). As in the case of chromosome aberrations, the form of dose-effect relationships for micronuclei were better described by a nonlinear function (Figure, polynomial, 2nd degree), in spite of the possibility of approximation by linear equations at significant coefficients of determination (for bone marrow $R^2 = 0.21$, $P<0.01$). It should be noted that the direct dependencies and a high degrees of causality between the frequencies of MN-PCE and γ-activity of incorporated radionuclides as well as estimated dose rates were detected for animals inhabiting the sites 2 and 4 (Spearman correlation coefficients were 0.74 and 0.68, respectively; significant at $P<0.01$).

Relationships between the frequencies of cytogenetic injuries (chromosome aberrations and micronuclei) and body burdens, estimated doses provide reasonable evidence of a biological efficiency of very low doses of chronic irradiation (2–730 µGy/day). Biological effects of
very low levels of chronic irradiation (0.4–5.5 μGy/day) in germ and somatic cells of pond carp were shown in our previous publication [7]. Our data on the genetic efficiency of low doses are in agreement with the results of the induction MN-PCE in Sweden bank voles in 1988 at 4.2–39.4 μGy/day following the Chernobyl fall-out obtained by Cristaldi et al. [8].

The applied analysis of dose-effect relationship based on individual genetic parameters and on individual absorbed doses proved to be a very sensitive method for revealing mutagenic activity of extremely low radiation doses. This approach can also serve for detecting biological activity of low levels of any factors. In this connection it is worth to note that the conventional use of chromosome aberration test in human lymphocytes in vitro can help in detecting of mutagenic effect of acute γ-irradiation at 0.05 Gy and above when repair inhibitor caffeine is applied [9].

Our results and the known facts [10] on the existence of linear dependencies in the range of low-doses (2–45 mGy) give evidence of the threshold absence. It should be noted that our observations of extremely low-dose effects on mammals and fish are not compatible with the values extrapolated from high-dose experiments. Unexpectedly high efficiency of extremely low levels of chronic irradiation raises some questions. One of them when interpreting such low-dose effect, low-LET radiation-induced DNA damages per mammalian cells/hour should be compared with endogenous DNA damaging events/cells/hour [11].

CONCLUSION.
Significant biological efficiency of extremely low doses of chronic irradiation, great vagueness in low-dose response patterns for dose curves, and existence in some cases dose-response curves exhibiting a plateau effects cannot be satisfactorily accounted for by the target theory added by availability of indirect effects. Elaboration of new theories for accounting for the above-stated and other phenomena is required.

ACKNOWLEDGEMENTS.
The authors wish to thank Dr. V.P.Kudryashov for analysing of concentrations of strontium and transuranic radionuclides in samples of soil and animals.

BIBLIOGRAPHY


CHRONIC RADIATION EXPOSURE AND LEUKAEMIA: DIFFICULTIES AND EXPERIENCES FROM THE NORD-COTENTIN RADIOECOLOGICAL STUDY

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ABSTRACT

The Nord-Cotentin study aims to: a) reconstitute radiation doses to the red bone marrow received by populations aged 0 to 24 years living near the La Hague nuclear site (France) between 1978 and 1996, b) estimate the associated risk of leukaemia, and c) compare it with the results of previous local epidemiological studies [Viel 1995] [Guizard 1997]. The Working Group in charge of the study [Groupe Radioécologie Nord-Cotentin 1998] includes nuclear operators, authorities, international experts and members of environmental organisations. The methodology developed focuses on:

1. the reconstruction of the cohort of people aged 0 to 24 years, by using local birth rates for the years 1954 to 1996 and taking into account the additional arrival of young people in the area,

2. the estimation of doses to the red bone marrow received from all sources of radiation (local nuclear industries, natural exposures, medical exposures and exposures from the Chernobyl accident and from nuclear arm testing),

3. the estimation of the risk of leukaemia from models recommended by the BEIR and the UNSCEAR committees,

4. the assessment of doses for typical scenarios based on specific behaviours leading to greater exposures (a high consumption of seafood or a long time spent on local beaches), as suggested by a previous epidemiological study [Pobel 1997]).

COHORT RECONSTRUCTION

The cluster of leukaemia suggested by the epidemiological study is related to the people aged 0 to 24 who have been living in the canton of Beaumont-Hague between 1978 and 1996. The aim of this step is to reconstitute, as exactly as possible from the existing demographic data, the population of 0-24 year old people who have been living in the canton. This population is named « cohort » but it is not strictly an epidemiological cohort. Indeed, there is no search of real individual data. The reconstruction is based on the yearly birth rates data in each of the 19 cities of the canton. Each individual born in the canton is supposed to stay there until the age of 25 (or up to 1996 if this age is not reached). Mortality rates taken into account are national data because local ones are not available.

It is necessary to account for the people’s migrations in and out the canton because the COGEMA enterprise built one of the reprocessing plant during the 1978-1996 period and many workers arrived there with their family to participate in the construction. The scholarship data are used to reconstitute the demographic variations of the cohort. These data show an increase of the population of the canton between 1983 and 1986 which can be linked with the development of the suburbs of Cherbourg and the construction of one of the reprocessing units of the COGEMA-La Hague plant. The Working Group took into account
this increase by assuming a punctual increase of the cohort in 1984 to simplify the dose calculations. The result of the reconstruction step appears on figure 1. The total number of person-years of the reconstructed cohort is 69308 between 1978 and 1996.

CALCULATION OF DOSE TO THE RED BONE MARROW
The concentrations of the radionuclides in the environment that are used as inputs in the dose calculation result from the combination of two approaches: the modelling of the transfer of the radionuclides released in the environment (81 radionuclides) and the use of environmental measurements. Four nuclear installations of the Nord-Cotentin area are considered: the reprocessing plant of COGEMA-La Hague, the nuclear power plant of EDF-Flamanville, the waste disposal of ANDRA and the naval dockyards of the French Marine at Cherbourg. The exposure pathways retained for the modelling are:

- **External exposure**
  - by the plume
  - by ground depositions
  - by the sand of the beaches
  - by the seawater during bathing

- **Internal exposure**
  - by inhalation of the plume, the resuspended particles and the seaspray
  - by ingestion of seafood and terrestrial food contaminated by the atmospheric and marine releases, the seaspray and the spreading of algae
  - by ingestion of sand, ground and seawater.

The most important accidental releases, the breaking of the release pipe of COGEMA in 1979-1980 and the fire of a storage unit of COGEMA in 1981, are taken into account by specific models.

The dose modelling uses the life habits of the local population (dietary habits, time spent, behaviours). The difficulty is to define the most realistic life habits for the cohort in the past.
The results from existing surveys are used as often as possible but the Working Group was obliged to make hypotheses when no local data were available. The values of dose coefficients to the red bone marrow come from [ICRP 1998]. These values were interpolated to calculate the equivalent dose delivered each year to the red bone marrow. Doses to the red bone marrow are calculated for each year between 1954 and 1996 and for five age groups. The total collective dose to the red bone marrow for the cohort, due to routine discharges, is 0.3 man.Sv (average per caput of 3 μSv.an⁻¹). Contributions of the major radionuclides are presented on figure 2. Collective doses added by the break of the pipe and the fire are respectively 0.04 and 0.14 man.Sv.

The other sources of exposure (natural, medical, the Chernobyl accident and the nuclear arm testing) are studied more globally because few local data concerning natural and medical exposures are available. The aim was only to allow a comparison with the doses due to local nuclear installations (Figure 3).
RISK ESTIMATION

The number of expected leukaemia is calculated using two models recommended by international groups of experts: the BEIR V model [BEIR 1990] and the UNSCEAR 1994 model [UNSCEAR 1994]. The UNSCEAR model is preferred because its application does not require background reference level of leukaemia incidence, which is not existing for the whole period in France. The estimation of the number of leukaemia due to the routine discharges from nuclear installations of the Nord-Cotentin is 0.0009 for the period 1978-1996. The number of leukaemia added by the break of the pipe and the fire are respectively 0.0001 and 0.0004. The total number of leukaemia estimated due to all exposure sources is 0.835. 74% are due to natural exposures, 24% to medical ones and 2% to the Chernobyl accident and nuclear arm testing. Nuclear installations of Nord-Cotentin contribute only for 0.1%.

ASSESSMENT FOR THE SCENARIOS

Individual dose and risk are assessed for four typical scenarios based on behaviours leading to greater exposure (a high consumption of seafood by the young people, a long time spent on local beaches by the young people or by the mothers during their pregnancy), as suggested by a previous epidemiological study [Pobel 1997]). Even a very intensive frequentation of local beaches (80 min per day) does not increase significantly the risk of leukaemia. The risk for a young individual consuming a very large quantity of local seafood (up to 500 g per day) is increased by a factor of 2 but this augmentation is essentially due to the ingestion of natural radionuclides, such as 210Po contained in the seafood.
CONCLUSION
The reconstruction of exposures to ionising radiation in the Nord-Cotentin leads to an estimation of 0.0014 cases of radio-induced leukaemia due to the local nuclear installations for the period 1978-1996. This number is low when compared to the incidence of leukaemia mentioned in the recent epidemiological studies (4 cases observed among 0-24 year old individuals living in that area between 1978 and 1996) but the uncertainty around this estimation is not quantified yet.

Two main difficulties had to be solved by the Working Group. The first one was linked to the retrospective character of the study and the unavailability of data for the past. This latter point was often at the origin of the second difficulty which was to find a consensus on working hypotheses in a group composed by operators, authorities and members of environmental organisations. On the other hand, this original composition of the Working Group gives some assurance for a critical analysis of the whole risk assessment process.

BIBLIOGRAPHY
UVB-INDUCED IMMUNOMODULATION: ESTIMATION OF THE HEALTH RISK

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ABSTRACT
Depletion of stratospheric ozone and changes in life-style might lead to an increased exposure to sunlight, including radiation in the UVB wavebands (280-315 nm). Besides beneficial effects, such as vitamin D production and skin-tanning, solar UV can induce deleterious effects on the eye and skin. The last two decades it became clear that UVB irradiation can induce modulation of the immune system also. Such damage may affect not only photocarcinogenesis but also the resistance to infections, certain allergies, autoimmunity, and vaccination efficacy. In the present study, the risk of increased UVB exposure has been estimated with respect to the immunomodulation and as a consequence effects on resistance to infections. The data indicate that suberythemal UVB irradiation may have significant effects on immune responses to certain infectious diseases in human subjects. The exact quantitative relations between immunosuppressive effects of UVB and an increased incidence or severity of infectious diseases in humans needs a cautious approach and follow-up studies including epidemiology are essential.

INTRODUCTION
Photobiologists, dermatologists, and oculists indicate that UVR is a potential hazard for human health because of its genotoxic, mutagenic, carcinogenic and immunotoxic properties. Effects of UVR include the induction of skin cancers, damage to the eye (cataract, inflammation, snowblindnesses) and impairment of resistance to certain infections. Even changes in certain allergies and autoimmune diseases are suggested also. Already in the early seventies and eighties it was demonstrated that UV can affect the immune system. Kripke et al. demonstrated that UV not only changes normal cells into cancer cells but also permits the outgrowth of the UV-transformed cells by depressing the immune system (Kripke, 1974, 1981). These mouse studies have triggered many other investigations aimed at unravelling the immunosuppressive activities of UV radiation. Many immune function parameters such as contact hypersensitivity (CHS), delayed-type hypersensitivity (DTH), mixed lymphocyte reactions (MLR), mixed skin lymphocyte reactions (MSLR) and antigen presentation have been examined extensively (Hurks et al., 1994). More recently, a number of studies have focused on the consequences of this immunomodulation for the resistance to UV-induced skin-tumours and skin associated herpes simplex (HSV) infections (Norval et al., 1994; Garssen et al., 1998a; Goettsc et al., 1998). Immunological resistance to HSV was down-regulated by suberythemal doses of UVB in rat and mouse models and even in humans. Other skin-associated infections that are thought to be influenced by UV irradiation are Leishmania, Mycobacterium leprae, and Candida albicans (Jeevan et al., 1989, 1992; Denkins and Kripke, 1993; Giannini, 1986). Because UV can induce systemic effects in addition to its local effects in the skin, it was suggested that the resistance to systemic, i.e. non-skin-associated, infections may also be lowered. Indeed, there is increasing evidence that UVB radiation can alter immunity to systemic infections. For example, it was demonstrated that immune responses and resistance to Mycobacterium bovis were significantly suppressed by UV exposure (Jeevan et al., 1989, 1992). In other studies the immune response to Listeria monocytogenes (a bacterium), Trichinella
spiralis (a parasite), HSV (systemic intranasal infection model) and cytomegalovirus (Goettsch et al., 1996a; 1996b; Garssen et al., 1995) were affected. In contrast, resistance to Schistosoma (Noonan and Lewis, 1995) and malaria were not altered by suberythemal UVB exposure. Based on our data with respect to the L. monocytogenes model and studies by De Fabo et al. (1990), a preliminary estimation of the risk of exposure of human individuals to increasing UVB, due to a thinner ozone-layer, was calculated (Garssen et al., 1998a; Goettsch et al., 1998). The mathematical model included information on the action spectrum for the suppression of contact hypersensitivity (De Fabo and Noonan, 1983) and dose response studies for suppression of T cell activity in the Listeria infection model, and the estimated biological effective irradiance at certain latitudes (De Fabo et al., 1990). In general it is accepted that, for UV to have a biological effect, it must be absorbed by a chromophore in the skin that translates the energy into a biochemical signal. Different candidates have been proposed to act as the UV-photoreceptor which are not mutually exclusive. First UV can alter the DNA structure directly (Vink et al. 1996; Hurks et al., 1995). Secondly UV can be absorbed by cellular components other than DNA, such as lipids in cell membranes, which generate oxidative DNA damage. In addition, lipid peroxidation reactions can trigger intracellular signalling pathways, which in turn may lead to gene activation. A third candidate is urocanic acid (UCA), found in the stratum corneum of the skin as the trans-isomer. Due to UV-irradiation, trans-UCA is converted into the immunosuppressive cis-isomer (Norval, 1996; De Fabo and Noonan, 1983). For example, in our studies it became clear that UCA isomerization played a pivotal role in UVB-induced immunosuppression leading to a lowered resistance to Trichinella (Garssen et al., 1999).

Because many mechanisms might be involved in UVB-induced immunosuppression, new risk estimations for decreased ozone layer thickness were performed. In these calculations, the action spectrum for DNA damage (Matsunaga et al., 1991), UCA absorption (De Fabo and Noonan, 1983) and mixed skin lymphocyte reactions (Hurks et al., 1995) were taken into account instead of the action spectrum for contact hypersensitivity as published earlier. The action spectra were used for the extrapolation of artificial UV exposure to solar UV exposure (what is the effective dose?).

METHODS AND RESULTS
For a quantitative risk assessment of impaired resistance to infections due to exposure to solar ultraviolet radiation the usual steps for risk assessment were followed: 1. hazard identification, 2. dose-response assessment, 3. exposure assessment, and 4. risk characterisation. Because experimental data on the effects of UVR on infectious diseases, easily obtainable in laboratory animals, cannot be acquired using human subjects for ethical reasons, and because epidemiological data regarding the incidence of infectious diseases are not readily available, the only way to estimate the risk for humans is to extrapolate from the animal data. The parallelogram approach was used for this, as published earlier (Van Loveren et al., 1997; Goettsch et al., 1998; Garssen et al., 1998a) (figure 1).
For step 1 suppressive effects of UV radiation on the immune system in rodents and human volunteers were analysed. For ethical reasons the effects on the resistance to infections were analysed only in animal models. Recently a model for systemic intranasal HSV infection in the rat was developed. The animals were exposed to the FS40 lamps followed by intranasal infection with the virus. HSV is neurotropic and homes to the ganglia and central nervous system. In some animals, depending on the virus load, the infection leads to clinical symptoms that reflect neurological damage (wobbling gait sometimes with paralysis, hyperexcited, jumpy). It was found that the virus load increased as the UVB dose increased, which was also true for the number/percentage of animals with the clinical symptoms. In step 2 dose response studies were performed in animals and human volunteers for immune function parameters and in the rat for resistance to intranasal infections with the herpes simplex I virus also. Using the dose-response analyses for immune parameters in both animal and human a factor for interspecies comparison as well as a factor for intraspecies comparison can be calculated. It was shown that the average human being was approximately 3-4 (for mixed skin lymphocyte reaction and natural killer cell function) times less sensitive than the rat to UVB. For differences between people, an additional factor of 0.5 was allowed. In order to extrapolate from rat to man, the dose (animal HSV infection study) was multiplied by uncertainty factors for inter- and intraspecies differences. In step 3 effects induced by artificial UV sources were extrapolated to effects induced by the actual solar UV exposure around noon in the Mediterranean. Different action spectra for several immune parameters in animal and man were used to extrapolate artificial UV exposure to the actual solar UV exposure. In step 4 the solar exposure required to increase the incidence of clinical symptoms by 10% (i.e. 10% more individuals with clinical symptoms) in the general human population was calculated/estimated and is shown in Table 1. In conclusion, solar UVB exposure impairs the immunological resistance to infections in rodents, and the calculated data appear to be relevant for the human situation.

Table 1.

Predicted effect of ozone depletion on solar exposure time necessary to increase the incidence of human subjects suffering from clinical symptoms due to herpes simplex virus infection by 10% at 40° N in July, clear sky, around noon. Artificial UV exposure was extrapolated to solar exposure using 4 different action spectra.

<table>
<thead>
<tr>
<th>% decrease in ozone</th>
<th>Estimated time in minutes (% reduction of exposure time between brackets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHS</td>
<td>DNA</td>
</tr>
<tr>
<td>0</td>
<td>302</td>
</tr>
<tr>
<td>5%</td>
<td>295(-2.3%)</td>
</tr>
<tr>
<td>10%</td>
<td>288(-4.6%)</td>
</tr>
</tbody>
</table>

CHS= action spectrum for contact hypersensitivity (De Fabo and Noonan, 1983); DNA=action spectrum for DNA damage (Matsunaga et al., 1991); UCA= Urocanic acid
absorption spectrum (De Fabo and Noonan, 1983); MSLR = action spectrum for mixed skin lymphocyte reaction (Hurks et al. 1995).

**DISCUSSION AND CONCLUSIONS**

Risk assessment is a process of analysing relevant biological, dose-response, and exposure data for a particular agent in an attempt to establish qualitative and quantitative estimates of adverse effects on human health. Such an assessment of the carcinogenic potential of UVB radiation is easier to determine than that of UVB-induced immunomodulation and, as a consequence, impaired resistance to certain infections. For risk assessment of the carcinogenic potential of UVB radiation, the adverse endpoint can be quantitated and is beyond dispute (i.e. skin cancer). In contrast, the impairment in T cell immunity to *L. monocytogenes* is difficult to quantify in terms of increased incidence or severity of disease (Goettsch et al., 1998; Garssen et al. 1998a). However with the HSV model the adverse effects can be defined as percentage of individuals with clinical symptoms and/or viral load increments. These endpoints for risk assessment may be more relevant than the impairment of one or two immune functions such as T cell and natural killer cell activity.

In conclusion, although a few infections in animal models are not affected by UVB exposure, most demonstrate decreased immunity. These results are likely to be relevant for the human situation because many of the effects described in animals can also be found in humans. The exact quantitative relationship between the immunosuppressive effects of UVB radiation and an increased incidence of infectious diseases in the human population needs a cautious approach, and prospective studies are required. Epidemiological and clinical approaches, as far as these are permitted ethically, may help to clarify the effect of UVR on human infectious diseases, and should be areas of future research.

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**REFERENCES**


COMPARIISON OF THE RISK ASSESSMENT AND MANAGEMENT OF IONISING RADIATION, ASBESTOS AND NICKEL

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ABSTRACT
This paper presents the main results of a study devoted to the comparison of the risk assessment and management of ionising radiation, asbestos and nickel in France. A carcinogenic risk has been recognised in the three cases. The objective of the analysis was to identify the similarities as well as the differences at three levels: concepts, regulation and practices. Ionising radiation (IR) is compared with asbestos as far as occupational exposure is concerned and to nickel and nickel compounds as far as general population exposure is concerned.

1. INTRODUCTION
Doubts have been expressed in recent years over the equity and social effectiveness of allocating resources to protection of the environment and health. A comparison of risk assessment and management practices in various industrial sectors is one way, among others, of addressing these concerns. In this perspective, the aim of this paper is to analyse the consistency of the assessment and management of different carcinogenic risks and to draw attention to the main similarities and differences. It addresses the carcinogenic risk assessment and management of ionising radiation, asbestos and nickel in France.

2. AT THE CONCEPTUAL LEVEL
The first part of the study is aiming at determining whether the various stages in the risk assessment and management procedure are applicable to the three case studies considered. In accordance with the procedure drawn up in 1983 by the US National Research Council [1], the risk assessment process is generally divided into three stages: hazard identification, determination of exposure-risk relationship, assessment of the number of people exposed and levels of exposure. There is also a decision-aiding stage based on the assessment of alternative prevention policies (risk management). Radiological protection provides the frame of reference for this latter stage. In 1977 the International Commission on Radiological Protection (ICRP) [2] drew up, and subsequently revised and enlarged [3], a decision-aiding framework designed to determine the dose levels that were “as low as reasonably achievable, economic and social factors being taken into account” (ALARA).

Proven carcinogenic effects on humans
Both epidemiological and animal studies have clearly and incontrovertibly demonstrated the carcinogenic properties of ionising radiation (IR), asbestos fibres and certain nickel compounds at levels of exposure which show excess incidence of cancer.
• The epidemiological studies carried out after the bombing of Hiroshima and Nagasaki in 1945 confirmed earlier observations of the excess incidence of leukaemia among radiologists. Now, these studies reveal evidence that IR could also cause other types of cancer such as cancer of the lung, digestive tracts, colon, breast, etc.
• Rigorous epidemiological evidence of the excess incidence of lung cancer among workers exposed to asbestos was provided for the first time in 1950. First testimony of a link between exposure to asbestos and mesothelioma was established in 1960.

• The excess incidence of lung and nose cancers attributable to high concentrations of mixed copper and nickel oxides as well as soluble nickel compounds emitted in nickel refinery was pointed out in the 1930s.

Existence of exposure-risk relationships
In all three cases, epidemiological studies demonstrated the link between relatively high levels of exposure and an excess incidence of cancer.

• In the case of IR, the main basis for risk quantification is the Life Span Study (93,000 survivors of the bombs dropped on Hiroshima and Nagasaki). The relationships deal with the incidence of leukaemia and solid tumours (lung, digestive tracts, colon, breast, etc.).

• The model which links cumulative exposure to asbestos to the increased risk of death from lung cancer is based on 11 cohort studies, while the relation between the concentration of airborne fibres and the increased incidence of death from mesothelioma (a multi-stage model) is adjusted for 3 cohorts and provides an absolute estimate of the increased incidence [4].

• In the case of nickel, ten epidemiological studies serve as a basis for the risk quantification. Exposure risk relationship refers to lung cancer and exposure to nickel sulphides and nickel oxides present in some nickel refinery [5]. Nevertheless, it should be noted that the exposure-risk relationship in the case of lung cancer and mesothelioma does not apply to discontinuous occupational exposures to asbestos with high concentration levels during short periods. Furthermore, while for specific nickel compounds no excess of cancer risk has been observed for occupational exposures, the lack of a precise chemical characterisation of the nickel compounds present in the environment leads to an assessment in terms of total nickel concentration, resulting in an over-estimation of the risk.

A shared assumption regarding the lack of threshold for low levels of exposure
In the case of all three agents, experts working in different sectors of activity consider that it is possible to make the cautious assumption that an increased incidence of cancer is associated with low levels of exposure. For the sake of risk-management, these experts adopted linear no-threshold exposure-risk relationships obtained by extrapolating the results of epidemiological studies related to higher levels of exposure down to lower levels of exposure. Therefore, the following excess individual lifetime risks of death from cancer by unit of exposure have been adopted:

<table>
<thead>
<tr>
<th></th>
<th>Excess Individual Lifetime Risk of Death from Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR: Workers</td>
<td>4x10^-5 per mSv</td>
</tr>
<tr>
<td>IR: General Public</td>
<td>5x10^-5 per mSv</td>
</tr>
<tr>
<td>Asbestos: Workers</td>
<td>4x10^-4 per year/[L/ml]</td>
</tr>
<tr>
<td>Nickel: General Public</td>
<td>1.4x10^-9 per year/[ng/m^3]</td>
</tr>
</tbody>
</table>

Assessment of future protective actions and choice of actions
In all three cases it is possible to use cumulative exposure to assess the predictive effectiveness of protective actions, subject to the limitation on sporadic exposure with regard to asbestos. Cumulative exposure and consequently the avoided health risk can be deduced
from the level and total duration of exposure. This approach should allow (at least at the conceptual level) to inform the choice of protective action in each sector and then to compare the cost of protective actions with the expected benefit in terms of reduced exposure, provided in monetary terms.

3. AT THE REGULATORY LEVEL

**Different status**

The status of the IR dose limits differs from the status of permissible exposure limits (PEL) set for asbestos and nickel. For IR, compliance with the dose limit cannot be seen as the final objective of protection: the burden is put on the requirement to maintain the doses as low as reasonably achievable, economic and social factors being taken into account (ALARA). In most of the situations, actual exposure to IR in industry appear to be significantly lower than the dose limit. With regard to asbestos and nickel, the PELs are set at values which reflect the aim of reducing the residual carcinogenic risk to a very low level. In practice, with regard to both nickel in the environment and asbestos in the workplace, achieving the PEL is the first, and often very ambitious, objective. However in all three cases, the PEL is not considered to be a threshold and it is accepted, as a precautionary measure, that below the PEL a residual risk still remains.

**Different basis**

The dose limits for IR and nickel are based on dose-risk relationships. The risk level associated with dose limits in the case of IR is set by the International Commission on Radiological Protection, notably through the comparison with the risk of death in other reputedly “safe” industrial sectors, with regard to occupational exposures, and comparison with the doses arising from natural background radiation in the case of members of the general public. No PEL for nickel in the environment has been established to date. The level eventually set would be based on the work of the World Health Organisation, which refers to an individual excess lifetime risk of fatal cancer of $10^{-5}$, although it is not a formal recommendation. In the case of asbestos, the PEL in France is not based on the exposure-risk relationship but on concerns of a different nature:

- According to one epidemiological study, the value of 0.1 f/ml is the lowest concentration that, over a period of 50 years, produces a statistically significant increased risk.
- It would also appear that 0.1 f/ml is in practice the limit for the sensitivity of the measuring instruments used in industry.

The PELs are set out in the table below.

<table>
<thead>
<tr>
<th></th>
<th>PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR: Workers</td>
<td>100 mSv over 5 consecutive years, annual dose less than 50 mSv</td>
</tr>
<tr>
<td>IR: General Public</td>
<td>1 mSv/year</td>
</tr>
<tr>
<td>Asbestos: Workers</td>
<td>0.1 f/ml, average over 1 hour</td>
</tr>
<tr>
<td>Nickel: General Public</td>
<td>10 to several tens of ng/m³</td>
</tr>
</tbody>
</table>

4. AT THE PRACTICAL LEVEL

The control policies implemented in the three cases are devoted to looking for the means which would appear to the stakeholders to be a reasonable compromise with regard to relevant criteria [6, 7]. The ALARA approach adopted for IR is also applied in the case of nickel, with some noticeable differences as far as the decision aiding procedures are concerned, e.g.:
• Seeking for the best available technologies, and taking into account the local environmental conditions,
• Defining and implementing regional plan for air quality, through the involvement of the stakeholders (regional authorities, industry, experts, neighbours, consumers...).

In the case of asbestos, notwithstanding the available prescriptive regulation, a margin of judgement of what can be considered as a reasonable control policy appears to exist. This margin is explained by the great variability of the exposure situations and also by the fact that a risk trade-off can result from an inappropriate use of the asbestos exposure reduction means (electric chock, falling down,...).

5. CONCLUSION
In this study, a quantitative comparison of risks in the various sectors is less important than a qualitative comparison of the risk-assessment and management approaches. The study therefore focuses on current practices and how they compare with each other. The data collected reveal some significant similarities in the principles on which the risk-assessment and management of low-level exposures are based. At the same time, the procedures which are actually used in practice, despite being based on relatively distinct instruments, ultimately produce results that in general reflect the shared concern to devise reasonable solutions with regard to the prevention of carcinogenic risks.

ACKNOWLEDGEMENTS
This work has been performed within the framework of a working group of the Committee on Radiation Protection and Public Health of the OECD Nuclear Energy Agency.

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A CASE OF IRRADIATION A GROUP OF THE WORKERS OF THE NUCLEAR POWER STATION BY IRIDIUM SOURCE OF DEFECTOSCOPE IN 1998 (STATE AND FORECAST)

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The cases when at contact with radioactive radiator had a place a beam defeat (an accident in Guyana, Brazil), both with opened and closed sources, are illustrated in the world literature. Describing these cases, the authors tend to state accounts or forecasts of risks.

The case of the non-authorized irradiation of 2 men - defectoscopers of a nuclear power station is described. One of them got beam burns of a palm and a haunch in 2-3 months after the accident. The accident was caused by the technical defect of an iridium source - defectoscope, which was not automatically loaded in safe capsule after work. The men were irradiated with dozes 0.60 Sv and 0.14 Sv. The results of the individual dosimeter (TLD) and calculations of a probable irradiation established the dozes. There was a subsequent insignificant irradiation of the nuclear power station personnel, which casually was in a defectoscopers' route.

Leukemia and solid tumors risks estimation following the accident is presented in the article.
RISK ANALYSIS OF DEPLETED URANIUM FOLLOWING AN AIRCRAFT CRASH

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ABSTRACT
In 1992, a large aircraft containing pieces of depleted uranium crashed into an apartment building complex in the Netherlands. A risk analysis of the depleted uranium was carried out in 1998. The results are presented here.

1 INTRODUCTION
On 4 October 1992, a Boeing 747 cargo plane crashed into an apartment building complex near Schiphol Airport in the Netherlands, leading to the immediate death of 43 people [1]. The aircraft, cargo, fuel and damaged apartment building caught fire immediately after the crash and burned for more than one hour. In the years following the accident, an increasing number of people began reporting various physical and mental health complaints, which they attributed to the exposure to dangerous substances during the fire after the crash. Especially depleted uranium was pointed out as a possible cause of their health problems, since the aircraft contained depleted uranium to function as counterbalance weight and because about 150 kg out of the total 282 kg uranium was missing following clearance of the crash area.

This paper presents the risk analysis carried out to determine whether the dispersion of uranium following the air crash could have led to long-term health complaints of bystanders present near the crash area. The reader is further referred to reference [2] for details not included in this paper. Reference [2] also describes the risk analysis, using a similar approach, of other hazardous substances issuing from the cargo or other burned material, such as HCl, PACs and heavy metals.

2 RISK ASSESSMENT
Literature studies and model calculations were used to estimate the exposure of bystanders to uranium and to evaluate the risk. The risk assessment aimed at giving conservative, but realistic results by using the most likely value for each parameter on the basis of the information available; conservative values were employed where no information was available. In addition to this, a worst-case approach was used to investigate the potential upper limit of the exposure.

3. LOCAL SITUATION
The local situation is shown in Figure 1. The aircraft collided almost perpendicularly into the intersecting point of an eleven-floor apartment building complex. Cargo was dispersed over a large area in front of the building and caught fire there. Two burning sites could be distinguished: namely, the site where the plane hit the apartments and the (rest of the) cargo plane ended up, and the site where cargo had been dispersed in the public garden in front of the apartment building. The surface area of the fire at the site of the crash was estimated at about 270 m², based on the area of the apartments which had collapsed. The (effective) area of the burning cargo in the public garden was estimated at a factor of 2 larger, i.e. 540 m². The duration of the fire was estimated to be one hour. At the time of the accident, a strong (12 m s⁻¹) northeast breeze favoured a strong dispersion of the contaminants.
The source term of smoke gases was derived from the burning rate in the fire and the burning area. The burning rate is estimated to be 0.05 kg m\(^{-2}\) s\(^{-1}\), based on typical values for kerosene and chemical waste [3,4]. Since the fire was in the open air, it was not oxygen limited. A stoichiometric air to fuel mass ratio is assumed, so that combustion of 1 kg kerosene results in 16 kg combustion products. The mass flows of combustion products generated in the fires were calculated at 216 kg s\(^{-1}\) and 432 kg s\(^{-1}\) for the crash and cargo sites, respectively. The heat available for plume rise per kg material burned is estimated to be 20 MJ [3,4,5].

### 4. SOURCE TERM OF DEPLETED URANIUM

The cargo plane contained about 24 pieces of depleted uranium, the mass of a single piece ranging from 6 to 30 kg, with specific areas of 0.05 – 0.15 cm\(^2\) g\(^{-1}\). Following the clean-up of the crash area, counter balance weights having a total mass of 152 kg uranium were missing. To date, it is still not known what happened to the missing uranium. The possibility exists that pieces of uranium were treated as ordinary waste material and dumped with the contaminated soil. Pieces of uranium may also have been (partly) oxidised in the fire and dispersed into the environment. In the analysis of this scenario, it is assumed that the pieces of uranium were evenly distributed over the two fire sites. To estimate the source term and its consequence, the oxidation rate, chemical appearance and particle distribution of the uranium oxide were determined. Based on a literature study, it is estimated that under the conditions likely to be present in these fires, a maximum of 30% of the missing uranium (46 kg) is oxidised within one hour [6]. The respirable fraction, i.e. the fraction having a particle size diameter less than 20 \(\mu m\), is less than 1 per cent by weight. The uranium oxides formed under these conditions are \(UO_2\) and \(U_3O_8\), which are poorly soluble [7]. The worst case approach assumes the total mass of the missing uranium to be located at the crash site and completely dispersed in respirable form.
5. DISPERSION OF SMOKE GASES AND URANIUM

Various models were used to calculate the dispersion of uranium and smoke gases in the environment, namely a very simple, rule-of-thumb calculation [8], a pool fire model in combination with a free-field dispersion model [9] and a 3D Computational Fluid Dynamics (CFD) model [10]. The results of the CFD calculations are shown in Figure 2.

The calculation shows the smoke gases from both the fires at the crash and cargo burning sites transported upwards through the newly created gap in the apartment building, leading to reduced concentrations at ground level. The results of the CFD calculations are confirmed by the available observations on video. The highest concentrations, found for bystanders situated in the area downwind of the crash site ranges from 1 - 10 g m$^{-3}$, where a minimum distance of 20 metres to the fire is assumed. The magnitudes of the smoke gas concentrations were confirmed by the other model calculations. Since the source term of uranium is very small relative to the amount of smoke gases, the presence of uranium will not affect the dispersion properties of the plume of smoke gases. The concentration of the aerosol-bound uranium in the environment can be derived from the calculated concentration of smoke gases by considering the mass fraction of uranium versus the mass fraction of the smoke gases. As a result, bystanders are calculated to have possibly been exposed to a concentration of uranium of 3 μg m$^{-3}$ (best case) for one hour; the upper limit is calculated as 2 mg m$^{-3}$ (worst case). Intake of uranium by inhalation in one hour is calculated at 4 μg (best estimate) to 6 mg (worst case).
6. EXPOSURE AND CONSEQUENCES
Since the uranium oxides formed in the fire are poorly soluble, the radiological toxicity is more important than the chemical toxicity. The intake of uranium by inhalation results in an effective radiation dose of 0.5 μSv (best estimate) to 0.7 mSv (worst case). The radiation dose is therefore comparable to eight hours of exposure to natural radiation in the Netherlands (best estimate). The radiation dose calculated in the worst-case scenario is comparable to the natural radiation dose in one year and is less than the yearly limit of 1 mSv for exposure to radiation by human action [11]. Inhalation of depleted uranium is therefore concluded as not resulting in detectable adverse effects to the bystanders.

7. CONCLUSION
On the basis of literature studies and model calculations, we estimated the exposure of bystanders to depleted uranium after a Boeing 747 aircraft crash. Various dispersion models used to estimate the concentrations of uranium in air yielded consistent results. The model calculations show that the concentrations and radiation doses were considerably below the levels at which acute health complaints can occur. It is therefore highly improbable that exposure of bystanders to uranium would result in the health complaints reported.

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DETERMINATION OF THE RISK FACTOR PROGRESS OF OSTEOPOROSIS FOR THE PATIENTS WITH ACUTE RADIATION SYNDROME

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The results of infrared (IR) spectral investigations of urine samples for persons with acute radiation syndrome (ARS) are represented. Osteoporosis is accompanied with increase of soluble forms of phosphates in bones. Changes of structure, chemical composition and physical properties of bones lead to changes of urine. It was shown that the dried urine infrared quantitative absorption spectra investigations of phosphates contents makes it possible to trace the changes of bone mineral part for liquidators (the persons, who took part in liquidation of Chernobyl catastrophe consequences).

1. INTRODUCTION

This investigation started with the necessity of complex diagnostics of some groups of liquidators. One of the most radiation sensitive cells of organism are proliferous bloodforming cells, therefore the bone marrow and the bone tissue. Among numerous reasons, provoked early beginning of osteoporosis, it was noted the action of radiation: many people with acute radiation syndrome (ARS) have the pains in the extremities. The reason of these pains may be osteoporosis.

For the comparison of osteoporosis degree we used our results of infrared spectral investigations of dried urine for persons with acute leucemia [1], who have pains of the bones. At the X-ray photographs of this patients one can observe small-cell osteoporosis [2,3].

Osteoporosis process is accompanied by changes in the mineral composition of the bones: of the acid (soluble) forms orthophosphates and the pyrophosphates forms accumulation takes place in the bone hydroxyapatite. Changes of structure, chemical composition and physical properties of bones lead to changes of urine. The infrared (IR) absorption spectroscopy gives the possibility to register the changes of daily urine composition and this way register the changes of bone tissue mineral part.

The mineral part of the bone consists of hydroxyapatite crystals (Ca_{10}(PO_{4})_{6}(OH)_{2}), besides it includes carbonates, fluorides and hydroxydes. Ca and P has a main role in many biological processes, which are responsible for cells operation. Changes of these elements domination lead to serious diseases. Physico-chemical equilibrium takes place at the boundary of bone tissue with surround media: from one side the elements come to the bone, and from another side they are eliminated from the bones. Ca and P are trasfered in the organism mainly as Ca^{2+} and HPO_{4}^{2-}[3].

Organic bone constituent causes the absorption bands, which are corresponded to amid-I, amid-II and amid-III groups the optical absorption is strong enough at 1660 cm^{-1}, 1540 cm^{-1}, and 1240 cm^{-1} respectively.

The mineral part of bone shows the IR absorption lines, which are characteristic for carbonate (CO_{3})^{2-} 880, 1430, 1460 cm^{-1} and for phosphate (PO_{4}^{3-}) compound. Orthophosphate tetraedral ion PO_{4}^{3-} (the symmetry T_d ) has four fundamental vibrations: symmetric valent vibration v_1 (A_1) and deformational doubly degenerate vibration v_2 (E); antisymmetric valent three times degenerate vibration v_3 (F_2), and deformational three
times degenerate vibration $v_4$ ($F_2$). The characteristic absorption bands of anion $\text{PO}_4^{3-}$
are 730, 850, 880, 960, 980, 1080, 1120 cm$^{-1}$ [4].

The simplest pyrophosphate anion is diphosphate-ion (pyrophosphate-ion), which
is formed by joining of the tops of two $\text{PO}_4$ tetrahedrons. At relatively simple structure of
$\text{P}_2\text{O}_7$ group it possesses of all the basic peculiarities of chemical structure of condensed
phosphate ions, which are connected with the existence and mutual influence of the bonds
of the type P-O$^-$ and P-O(P). The characteristic absorption bands of anion $\text{P}_2\text{O}_7^{4-}$ are
710, 73-740, 760-770, 840, 890-900, 920, 980-990, 1060 cm$^{-1}$ [5].

2. EXPERIMENTAL RESULTS AND DISCUSSION

The investigations of the molecular spectral transmission at 400-2000 cm$^{-1}$ region was
obtained by means of automatic set-up, based on grating spectrometer IKS-31 (infrared
spectrometer, model 31) with resolution better than 0.2 cm$^{-1}$.

There were analyzed more than 20 IR-spectra of dried urine samples for healthy persons
and above 20 IR-spectra of dried urine samples of patients with acute radiation syndrom
(ARS), which took part in liquidation consequence of Chernobyl catastrophe. Dried urine
samples were prepared according to the method, which was described in the previous
papers, for example [1*].

Study of absorption bands location and their configurations gives the possibility to make
some conclusions about the character of phosphates which form the composition of the
samples. The relative intensity of the absorption bands, which is proportional to their
square, is the measure of substance concentration in the sample investigated.

It was discovered, the IR absorption spectra for healthy persons differ from the spectra for
those with ARS and leucemia (see Fig.1).

Fig.1. Dried urine absorption spectra for healthy person (kontrol), for person with acute
radiation syndrome (ARS) and for person with acute leucemia (leucemia).
Fig. 2. Dried urine absorption spectra in 700-800 cm\(^{-1}\) spectral range for healthy person (kontrol), for person with acute radiation syndrome (ARS) and for person with acute leukemia (leucemia): 1 are Lorenzian absorption bands of the spectra for person with ARS.

Fig. 3. Dried urine absorption spectra in 800-1000 cm\(^{-1}\) spectral range for healthy person (kontrol), for person with acute radiation syndrome (ARS) and for person with acute leukemia (leucemia): 1 are Lorenzian absorption bands of the spectra for person with ARS.
In the case of dried urine IR absorption spectra for persons with ARS one can note qualitative differences. There are rather intensive absorption band with 730-740, 756-770, 910-930 and absorption lines at 960 and 982 cm\(^{-1}\) (Fig. 2,3). At the same time the absorption band in the region of 720-740 cm\(^{-1}\) becomes wider. For identification of phosphate type which is withdrawn from organism with urine we used the special program, which gives the opportunity to resolve the Lorencian type absorption bands. It was detailed analyzed spectral region 700-1000 cm\(^{-1}\), which seemed the most informative. In this range in the optical transmission spectra of the urine for healthy persons there are observed the absorption bands, which are characteristic for orthophosphate compound which is Ca(H\(_2\)PO\(_4\))\(_2\) -730, 756, 854, 883, 1078 cm\(^{-1}\) (see Fig.2,3). Absorption line at 720 cm\(^{-1}\) is connected with light absorption in vaseline.

In the IR-spectra of samples for persons with ARS one can mark out the absorption bands which can be attributed to phosphate Ca(H\(_2\)PO\(_4\))\(_2\) and we must to attract attention to the existence of the absorption bands of pyrophosphate compounds. They are (Ca\(_3\)H\(_2\)(P\(_2\)O\(_7\))\(_2\):4H\(_2\)O) with the maxima of absorption bands at 713, 736, 767, 896, 922, 980 and 1030 cm\(^{-1}\), (CaH\(_2\)P\(_2\)O\(_7\)) with the absorption peaks at 738, 840 900, 917 and 990 cm\(^{-1}\) (Fig.3). Changes of chemical composition of bones (and therefore of urine) are accompanied by the phosphate form changes - pyrophosphate forms accumulation in bone apatites. The pyrophosphate compounds are more soluble than orthophosphate compounds - coefficient of solubility of H\(_3\)PO\(_4\) is lower by a factor of 1.4 than coefficient solubility of H\(_2\)P\(_2\)O\(_7\). Therefore bone tissue resorption takes place. Changes of bone tissue mineral part can lead to osteoporosis.

3. CONCLUSION
We noted abnormally high elimination of more soluble calcium phosphate compounds allows one to suppose the presence of weak osteoporosis process. At the same time this changes of dried urine mineral composition for personal with ARS are not so considerable, as changes of dried urine IR spectra for the patient with acute leukemia, who have pains of the bone, which is accompanied of osteoporosis.

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TRACK 5
SESSION 3
CHERNOBYL – ACCIDENT MANAGEMENT
Track 5
Session 3
Chernobyl Accident Management
PECULIARITIES OF DESIGN AND REALIZATION OF COUNTERMEASURES TO PROVIDE RADIATION SAFETY UNDER UNSTABLE DEVELOPMENT OF SOCIAL SYSTEM

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ABSTRACT
As a rule justification of the intervention and optimization of long-term countermeasures to provide radiation safety of the population is based on predicted social-political and economic development of society. That assumes to be a very important initial term because to calculate the values of basic parameters such as a reference value for the cost of the man-Sievert it is used the data on annual gross national product, life expectancy, risk perception by public. Unpredictable changes of social-political and economic development of society may led to necessity to reevaluate of implementation of long-term countermeasures. For example, it may resulted from significant reduction of financial and technical resources planned to be used as well from change of public priorities, and therefore change of ranks of factors, accounted for making an optimization decision. ALARA review, which is part of optimization procedure, is used at the stage of implementation of countermeasures to introduce necessary corrections, caused by internal, local factors and does not take into account influence of external factors connected with changes in society. At the stage of implementation of countermeasures it appears to be necessary to provide time to time evaluation to clarify how significantly social-political and economic processes in society influence on countermeasures. For such estimation it is of sense to design criteria, which cover the range of influence from nonsignificant to force majeure. As an example it is considered influence of the above mentioned processes in a society on countermeasures aimed at relocation of the inhabitants of the three republics Belarus, Russia, and Ukraine, affected by the radioactive fallout due to the Chernobyl accident. The plans to relocate population affected, developed within the one state the USSR and had been realized up to the end of 1991, were changed significantly after collapse of the former USSR and creation of independent states.

As it is known the main remedy to receive an optimization decision in radiation protection is the ALARA procedure. Under implementation of the ALARA procedure at the stages of: (1) identification of the options and factors, (2) quantification of factors for each options, and (3) comparison and selection of options it is assigned the corresponding rank to each factor and different variants are compared by using the value of alpha (cost per unit collective dose). To assign the corresponding rank to each factor it is used the information on public priorities and degree of social perception of radiation risk. To estimate the value of alpha it is often used the data on annual gross national product, number of population, the loss of life expectancy associated with a Sievert. High-level decision-making planned to be realized for a long time is carried out with taking into account the prognosis of social-political and economic development of a society. To make necessary correction into realization of the accepted countermeasures it is applied an ALARA review, which is complementary tool to help ensure that radiation protection is optimized during operations. As a rule an ALARA review allows to take into account the corrections caused by internal, local factors and does not account for the influence caused by external factors depending on the processes in a society. But unforeseen changes in social-political and economic development of a society inevitably affect the implementation of the countermeasures being carried out. It appears to be of sense
at the stage of operation (for example, during an ALARA review) to provide evaluation whether current social-political and economic processes provide substantial affect on implementation of the countermeasures. One can judge about degree of such affect on the basis of comparison of the ranks of the factors at the stage of making decision with current ones, as well as using the same comparison procedure with respect to the value of alpha. If the ranks of the factors have not been changed and the new value of alpha does not led to selection of another optimum variant it can be considered that affect of changes in society development on implementation of the countermeasures is not substantial. Otherwise it is necessary to carry out the ALARA procedure again under use of new set of initial information. It also looks like of sense in the framework of the ALARA procedure at the stage of sensitivity analysis to identify the range of alpha value variation as well as the ranges of variation of the other factors. If during the implementation of the countermeasures the current alpha value or the values of the factors are observed to be outside of the corresponding ranges it is necessary to carry out the ALARA procedure again.

In April 1990 the Supreme Council of the USSR adopted a “State All-Union and Republican Programme for Urgent Measures for Eliminating the Consequences of the Chernobyl Accident for 1990-1992”. This three year programme proposed a large spectrum of measures to decrease level of exposure to population and to improve the living conditions of the inhabitants in the contaminated areas of the three republics: Belarus, Russia, and Ukraine. Very tough dosimetric criteria were used as a basis for that programme. According to these criteria the residents with effective dose (due to the Chernobyl accident): (1) ≥5 mSv y⁻¹ (on average, it corresponded to a level of $^{137}$Cs ground density more than 555 kBq m⁻²) should be relocated, (2) in the range of (1-5) mSv y⁻¹ (it corresponded to approximately (185-555) kBq m⁻² of $^{137}$Cs) have a right for a voluntary relocation, and (3) <1 mSv y⁻¹ and range of (37-185) kBq m⁻² of $^{137}$Cs ground density have a favorable social-economic status.

As the basis for establishment of such tough criteria it was not used the information received from accumulated world experience on the radiobiological results of the influence of the ionizing radiation with accounting for available social-economic level of development of society, but sharp negative perception of radiation risk by public. According to the State programme about 225,000 inhabitants (114,400 in Belarus, 85,500 in Russia, and 25,000 in Ukraine) should be relocated to “clean territories”.

In 1990-1991 in the framework of the International Chernobyl Project it was carried out the ALARA procedure aimed at analyzing the justification of the accepted decision regarding only two countermeasures: (1) relocation and (2) improvement of the living conditions of the population in the contaminated areas. Certainly, that relocation of the population to “clean territories” resulted in greater decrease of collective dose than improvement of the living conditions of the population in the contaminated areas by provision of “clean food” and other measures. However and the cost per capita in case of relocation were as higher as more than 5 times in comparison with case of improvement of the living conditions.

The estimates received by the experts of the International Chernobyl Project showed [1] that to decrease 1 man-Sievert of the collective dose in case of relocation from only the territory contaminated with the $^{137}$Cs ground density more than 2960 kBq m⁻² it is necessary to spent about 80,000 roubles. At the same time the value of alpha had been calculated by that time did not exceed 5,000 roubles i.e. relocation of the population living even in the territories with such level of $^{137}$Cs density was not justified from the cost-benefit analysis point of view. It is
necessary to mention that the social-psychological factors were not taken into account during the implementation of the ALARA procedure.

It should also be noted that a large fraction of money spent in the framework of the above mentioned State programme and spent in the following years in the framework of the other programmes did achieve little or no reduction in collective dose. In fact, it was the consequence that most of the allocated resources were direct or indirect compensation for those who may have been affected by the accident, mainly from the psychological point of view, in order to improve the public acceptability of the situation.

Collapse of the USSR at the end of 1991 and increase of the economic crises in the three countries led in each country to approve their own programmes aimed at the mitigation of the consequences of the Chernobyl accident.

In Russia during 1992-1998 it occurred a sharp reduction of the funds (in a comparative cost) allocated to the foundation of the programmes “Chernobyl” as high as 100 times, and to the programme “Children of Chernobyl” as high as 5 times. In Belarus during the same period of time it was allocated about 10% of state budget [2]. In 1992 it was established special Chernobyl duty (the main source of budget income) which was 18% of labour for all the enterprises located on the Belarussian. Because of economical crises that duty was decreased to 12% in 1994 and to 4% in 1998. Decrease of the actual size of the state budget also led to sharp decrease of the funds allocated to the mitigation of the consequences of the Chernobyl accident. In Ukraine during 1992-1997 in spite of economical crises it occurred even some increase about 60% (in a comparative cost) of the funds allocated to the mitigation of the consequences of the Chernobyl accident [3]. At the same time the structure of the allocated funds in Ukraine has been changed substantially, in 1992 about 40% of funds were directed to social cost, but in 1997 already 75% of funds were directed to social cost. Such changes are also observed in Russia and Belorussia.

Thus, an important tendency is observed in practice - fraction of social cost in the funds allocated to mitigate the consequences of the Chernobyl accident has grown up with time and becomes the dominant one independently whether the actual size of funds is increased or decreased. It means that the fraction of funds directed to the countermeasures on radiation protection has been decreased with time. Just distribution of these funds can be optimized by use of the ALARA procedure. In principle, the ALARA procedure applied to optimize the intervention is able to take into account the social factors, but its main direction is decrease of radiation risks. At the same time the main direction of social cost is decrease of social risks. Taking into account that social cost becomes the dominant one, it appears to be of sense to collect all the social factors into one block and to provide optimization of the social cost within the framework of that block. Under that optimization it can be inserted the relationship between the level of social risk and the value of residual collective dose.

Summing up the above mentioned, it should be noted that a “classical” approach to provide radiation protection in a post-accident situation, when radiation factors were taken into account predominantly proved its necessity and effectiveness in the short and medium term following the accident. However, in the longer term, as the Chernobyl experience shows, social-psychological factors become the dominant ones. Though that tendency is revealed for the countries with unstable political and economic systems, it appears they can be observed for the countries with stable development of society, but can be more weak. So in the longer
term the procedures to provide optimization of the funds allocated to radiation protection and to social cost should be carried out separately taking into account that the former is directed to decrease the radiation risks and the latter is directed to decrease the social risks.

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THE USAGE OF COST-BENEFIT RATIO IN RISK ASSESSMENT OF REGION CONTAMINATED BY CHERNOBYL ACCIDENT

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INTRODUCTION
Radiation contamination of the territories caused by Chernobyl accident lead to appearance of sources of ion irradiation to people in the environment. Radiation protection of population residing on the contaminated territories consist of a comprehensive complex of activities designed to reduce radiation doses by the population and creating a database of norms and methods that provides legal, scientific and methodological support to these activities [1].

The solution of the task of estimation of efficiency of these measures is impossible without development of the mathematical model for solution of task of optimum control of risk of ecological and technogenic catastrophes in Alienation Zone (AZ) of Chernobyl. The basis of such development can be the method of risk assessment of ecological and technogenic catastrophes offered in [2]. It is based on use of the theory of catastrophes and theory of optimum control and allows to find an optimal ratio of cost/benefits describing efficiency of use of means, going on decrease of risk of catastrophes [3].

The objective of this work is the development of appropriate mathematical model and determination with its help of effective dynamics of redistribution of means on various measures directed on decrease of risk of ecological and technogenic catastrophes, and decrease of pollution level in AZ of Chernobyl.

SYNTHESIS OF MATHEMATICAL MODEL OF THE AZ OBJECT
AZ is an open system with a point of view of mathematical modeling with intake of funds that are used for production, which is accurately recorded.

1. P - population,
2. Y - money equivalent,
3. Z - level of environmental contamination,
4. M - power of binding of pollution;
5. \( V^+ \) - stream of money resources.

The model will be based on the following assumptions:
1. The function M in a AZ is directed mainly on binding of radioactive wastes (object «Shelter», various storage places etc.)
2. Decreasing a level of resources will result in release of part of the radioactive wastes, connected by them, and increase of total level of pollution in AZ.
3. \( V^+ \) includes money resources directed on restoring of the resources (UR), on liquidation of technogenic pollution (UZ), on reproduction of base capital (Uv), on preventing of migration of pollution for bounds of AZ (UT).
4. There is a stream of pollution from AZ (IZ), connected with fires, high waters, migration of wild animals from AZ. This stream can be regulated by the value UT.

\[
V^+ = V^+(t), \quad P = P(t),
\]
\begin{align*}
\frac{dV}{dt} &= PCvV_m - \frac{V}{T_v} + \frac{U_vV^+}{C_{v_l}}, \\
\frac{dZ}{dt} &= PZv - \frac{Z}{T_z} - \frac{V^+U_z}{C_z} - I_z, \\
\frac{dM}{dt} &= -PM_m + \frac{V^+U_m}{C_m} \tag{4}
\end{align*}

Here \( P \) and \( V^+ \) are table functions, determined on the base of empirical data analysis; \( V_m, \ Z_v, \ M_m \) are table functions, determined in a result of solution of task of parameter identification for model (1), \( C_M, C_z, C_v, C_{v_l}, T_v, T_z \) are model parameters.

For account of risk of occurrence of extreme situations in AZ connected with violation of ecological and technogenic safety we use the results [3]. In this work for risk account the universal deformation of theory of catastrophes (cusp) was used. The value of risk was the degree of approximation of cusp parameters (value of a load on ecological system and its reserves) to their bifurcation values. In our case the value \( I_z \) is a load, and \( V^+ \) is reserves. Then the value of risk (\( R \)) will be calculated with the help of the following expression:

\[ R = \frac{I_z}{I_{z0}} \tag{5} \]

where \( I_{z0} \) is bifurcation value of \( I_z \).

Account of the strategy of redistribution of means for optimum control of risk of technogenic catastrophes in Alienation Zone.

The task of optimum control of risk of technogenic catastrophes in AZ was put with the purpose of determination of dynamics of redistribution of allocated means (control influences \( U_R, U_Z, U_T \)), which would allow to the given time moment to minimize a risk level and level of pollution, on the one hand, and to maximize the value of funds made in AZ.

On fig. 1 the results of solution of the task of optimum control are given. The task was solved to minimize levels of risk and technogenic pollution and maximize quantity of made production (white squares). The plan financing of pointed measures [4] is shown by black squares.

It is necessary to mark, that the given task concerns to the minimax type, as includes the competitive objectives. The dynamics of change \( U_R + U_Z = U_{RZ} \) and \( U_T \), allowing to minimize the value \( R \) and to maximize the value \( V \), is calculated on interval of modeling 1991 - 1996 years. As it is visible from figures, the introduction of optimum control results in decreasing of levels of pollution and risk, and also to increase of a level of made funds.

The carried out model research has shown, what even within the framework of simple reallocation of means between various measures connected to liquidation of consequences of Chernobyl accident, it is possible to achieve positive result - decreasing of risk of occurrence of extreme situations in AZ. The further improvement of the model will allow to solve wider circle of tasks considerably expanding possibilities and efficacy of work of plan organization in AZ.
CONCLUSION
In summary it is necessary to note, that main result of this work is the adaptation of a
method of risk assessment of ecological and technogenic catastrophes offered in [2,3], to
solution of practical tasks of control in AZ. The created software product can be used for
cost/benefits analysis at realization of various nature protection measures in AZ. It will
allow to determine: 1) the projects which are most perspective for financing; 2) optimal
amount of works giving maximum efficiency of use of funds; 3) optimal allocations of
means between various types of nature protection measures and other kinds of activity in
AZ.

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SOFTWARE FOR EFFICIENCY ESTIMATION OF EMERGENCY RESPONSE

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ABSTRACT
In the work was carried out the analysis of influence of emergency response on possible losses among staff and population. The results obtained in the work allow with the quantitative risk analysis to take into account the different kind of emergency response. The special software module was developed for simulation of emergency response in quantitative risk analysis. The software allows solving the optimization tasks on definition the optimal structure of forces and tools on emergency response.

INTRODUCTION
To the present time are well known the emergency response allowing to lower possible consequence of incidents and accidents. There are various methods of efficiency estimation for emergency response. In the work the quantitative risk analysis was applied.

The special software module that is taking into account actions on localization and liquidation of failures was added in a standard risk analysis program for the account of emergency response.

Description of software module
The work with the module assumes two stages: preliminary and calculation.
1. At a preliminary stage (before account) the actions of the personnel and emergency systems are defined for each possible emergency. The module admits the following actions on localization and liquidation of emergencies:
   • close/open a latch, valve No...;
   • switch on/switch off fire system;
   • pass peoples from a zone No... to a zone No....
   • switch on/switch off system of the notification, No of a signal
Result of a preliminary stage is the table "Emergency Response" of the following structure.

<table>
<thead>
<tr>
<th>Emergency</th>
<th>Time</th>
<th>Action</th>
<th>Parameters of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of a possible malfunction, such as outflow on capacity No..., gas pollution in a zone No... is value of field "Emergency";

Time, through which after occurrence of a malfunction the action will be executed, is value of field "Time";
Code of action on localization and liquidation of emergencies is value of field "Action";
The information about the characteristics of action (such as valve No, zone No ...) is value of
field "Action".

2. Calculation part of the module. The check on event described in the table "Emergency
Response" the field "Emergency" is added in the standard module of construction of events
tree.

Further with construction of a tree of events the actions described in the table "Emergency
Response" the field "Action" are taken into account.

Changing a set of actions, their parameters are possible are to traced by a degree of influence
of various kinds emergency response on failure consequences (in our case on humanitarian
losses among the personnel and population).

RESULTS
The module was fulfilled with realization of the quantitative analysis of risk of one of
LUKOIL refinery. By result of work were the recommendations
• By amount and places of accommodation of means of individual protection,
• By amount equipment of fire services and medical services,
• On updating the plans of emergencies liquidation.

Use of these recommendations allows to lower humanitarian risk for the personnel refinery
with $4.1 \times 10^{-4}$ up to $3.8 \times 10^{-4}$.

CONCLUSIONS
The results obtained in the work, allow with the quantitative risk analysis to take into account
the following emergency response:
• the notification of staff and population;
• use of individual protection tools;
• protection of staff both population in shelters and refuges;
• rendering of the mutual aid.

The application of the given approach allows to receive the quantitative recommendations for
reduction of humanitarian risk.
The further perfection of the approach sees in expansion of actions set processed by the
module.

BIBLIOGRAPHY
EFFICIENCY OF SHORT TERM COUNTERMEASURES IN CASE OF A SEVERE NUCLEAR ACCIDENT: A DYNAMIC POINT OF VIEW.

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In case of a severe nuclear accident at PWR plants, countermeasures should be initiated in the short term by authorities to reduce the consequences of the atmospheric radioactive releases on the neighbouring population. Various factors influence the level of protection afforded by the countermeasures. For instance, a too early intervention would lead to a lack of efficiency in terms of dosimetric impact if the actual evolution of the accident is not considered. Thus, countermeasures should be optimized. In general, the projected doses (those without applying any countermeasure) are compared with those expected for a particular countermeasure or strategy, the dosimetric efficiency being estimated for the total duration of the release. In this paper, an in-depth analysis associates the kinetics of the release with the corresponding evolution of the dosimetric efficiency of countermeasures. This is done at different times in the short term of the accident and for various distances from the accidented plant. Results are presented for different strategies initiated at various times. This work is intended to improve the early management of a major nuclear accident.

1) THE ACCIDENT SCENARIO
The accident considered in this study is regarded as the most severe which could happen in France. It is based on the hypothesis of the default of many systems, like the security injection, and a fast fusion of the core. The chronology of the release is given in Figure 1.

![Chronology of the release](image)

$t_0$ refers to the activating of countermeasures by authorities in order to protect the potentially exposed population. $t_1$ is the beginning of the core fusion and of the release through the containment leaks. $t_1$ - $t_0$ can range from one hour to a few hours, depending on the accident kinetics. During the first 24 hours, $1/10$ of the aerosols in the source term is considered to be released. At $t_1$+$24h$, the sand filter is opened to lower the pressure in the containment building and to avoid the uncontrolled release of radionuclides in the environment. During the second 24 hours, $9/10$ of the aerosols in the source term and most of noble gases are released.

2) PROJECTED DOSES TO THE PUBLIC IN CASE OF NO PROTECTIVE MEASURES
The study focuses on the short term of the accident, that is from 0 to 48 hours after the beginning of the release. The dosimetric consequences of the accident are evaluated for both adults and one-year-old children, in the vicinity of the accidented power plant (from 1 to 20 km). Dose assessment is made by the SIROCCO code [1], with the hypothesis of a 5 m.s$^{-1}$ wind speed, a stable atmosphere and in absence of rain. Figure 2 represents the evolution in time of the projected individual effective dose and its decomposition through the internal and external pathways, for an adult at a distance of 5 km from the plant. The large increase of the doses 24 hours after the beginning of the release is due to the opening of the sand filter. Thyroid and effective doses at different times and for various distances are reported in table 1.
**In France, intervention levels are recommended by the Ministry of Health [2]. They represent the projected dose above which a protective measure should be initiated. Sheltering is recommended when the projected effective dose exceeds 10 mSv, whereas evacuation is recommended when this dose exceeds 50 mSv. The intake of stable iodine is recommended when the thyroid dose exceeds 100 mSv for the most sensitive population. These recommended levels are used here. For the no protective measure scenario, the 50 mSv level for the effective dose is exceeded for both adults and one-year-old children up to 1 and 2 km, 24 h after the beginning of the release, and the 100 mSv level for the thyroid dose is exceeded for one-year-old children, up to 3-4 km. At the end of the release (48 h), the 50 mSv effective dose criteria is exceeded on a distance close to 5 km for adults and on a distance between 6 and 7 km for children. The thyroid dose criteria is exceeded up to 19 km for children.**

**3) PROTECTIVE MEASURES**

Protective measures envisaged in the early phase of the accident are evacuation, administration of stable iodine and sheltering. Evacuation is fully effective when realized before the release; as long as evacuation is not completely realized, no reduction factor is applied to the doses. The maximum benefit of stable iodine is clearly obtained by taking tablets before exposure to radioiodine or as soon as possible afterwards; its effectiveness decreases with time. From [3], we set up the effectiveness in reduction of the thyroid dose from inhalation of radioiodine to 90 % for the first 24 hours after the intake of stable iodine and to 75 % for the second 24 hours. A single intake of stable iodine is envisaged here. Sheltering provides a reduction of external doses. If windows and outer doors are closed, as well as ventilation systems, doses from inhalation of radionuclides can also be reduced but the effectiveness decreases with time. Long term sheltering (more than 48 h) should not be considered because of the social problem it may induce. The protection factor (PF), defined as the ratio between the dose received indoor and the dose received outdoor in absence of protection depends on the air exchange rate and on the characteristics of the house. Based on a previous study [4], various PF values are given in table 2.
4) CASE STUDY COMBINING SHELTERING + STABLE IODINE INTAKE

Two strategies, based on the combination of sheltering and intake of stable iodine are presented. The strategy ST1 assumes that people remain home-sheltered from the beginning of the release to its end and that they take their iodine tablet just before or simultaneously to the first release (at \( t_1 \)). The strategy ST2 rests on the same hypothesis for the sheltering but stable iodine is taken at \( t_1 + 24 \text{h} \). In strategy ST2, because of the decrease of the stable iodine efficiency, members of the public should be better protected against the radioiodine released between \( t_1 + 24 \text{h} \) and \( t_1 + 48 \text{h} \).

Figure 3 compares the evolution in time of the effective and thyroid doses when ST1 and ST2 are implemented. The dosimetric gain is expressed as the ratio of the dose when the strategy is implemented divided by the projected dose. Table 3 gives some dose values.

![Figure 3: Dosimetric gain for strategies ST1 and ST2](image)

The curves rise slightly with time because of the decrease in sheltering efficiency. The important rise of the ST1 curve after 24 hours is due to the loss of the stable iodine efficiency with time. On the contrary, the decrease of the ST2 curve shows the better protection brought by the belated intake of stable iodine.

It can be deduced from the plots that ST1 is most effective—in terms of dose reduction—the first 30 hours. After, ST2 becomes most effective. Twenty four hours after the beginning of the release, the thyroid dose estimated for ST2 is nearly 4 times higher than the one estimated for ST1, whereas at the end of the release (48 h), the dose evaluated for ST1 exceeds by a factor 1.6 the dose estimated for ST2. On the overall one can say that ST2 is better than ST1.

Table 3: Estimated doses (mSv) when ST1 and ST2 are implemented

<table>
<thead>
<tr>
<th>Distance</th>
<th>24 h ST1</th>
<th>48 h ST1</th>
<th>24 h ST2</th>
<th>48 h ST2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adult</td>
<td>1-yr child</td>
<td>Adult</td>
<td>1-yr child</td>
</tr>
<tr>
<td>1 km - effective dose</td>
<td>12.5</td>
<td>11.6</td>
<td>216</td>
<td>298</td>
</tr>
<tr>
<td>5 km - effective dose</td>
<td>0.7</td>
<td>0.6</td>
<td>11.5</td>
<td>16.1</td>
</tr>
<tr>
<td>1 km - thyroid dose</td>
<td>29.4</td>
<td>71.5</td>
<td>1771</td>
<td>3572</td>
</tr>
<tr>
<td>5 km - thyroid dose</td>
<td>1.6</td>
<td>3.8</td>
<td>97</td>
<td>195</td>
</tr>
</tbody>
</table>

Despite the implementation of ST1 and ST2, the doses at 48 h still remain important, which justifies the study of a strategy requiring the evacuation of the closest area.
The strategy ST3 hereafter supposes a fast fusion of the core (t_l to t_o is about one hour) and countermeasures vary with the distance from the plant. Four geographical zones are defined. In Zone 1 (0 to 3 km), people are expected to be sheltered at home very early, so near t_l+1h. They are asked to evacuate and to take stable iodine near t_l+2h (stable iodine must have been previously distributed in this area). Zone 1 is completely evacuated before t_l+4h. In Zone 2 (3 to 5 km), people are expected to be sheltered at home before t_l+4h. At this time, authorities decide to evacuate this area and recommend people to take stable iodine (stable iodine must have been previously distributed but a complementary distribution is also envisaged). The evacuation of the downwind sector is expected to last 2h, while the evacuation of the whole area takes 5h. In Zone 3 (5 to 10 km), people are expected to be at home with stable iodine (provided in distribution centers) around t_l+11h. The demand to take stable iodine occurs at t_l+12h and people are warned to stay at home till the end of the release. In Zone 4 (10 to 20 km), at t_l+11h, people are asked to pick up stable iodine and go home to shelter. These actions should be completed around t_l+19h. People are then asked to take stable iodine around t_l+21h before the major part of the release begins.

Table 4 presents the doses estimated when ST3 is implemented. In zone 1 and 2, people are not exposed any longer after respectively t_l+4h and t_l+6h.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Effective dose (mSv)</th>
<th>Thyroid dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adult</td>
<td>1-yr child</td>
</tr>
<tr>
<td>Zone 1</td>
<td>1 km</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>2 km</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>3 km</td>
<td>2.3</td>
</tr>
<tr>
<td>Zone 2</td>
<td>4 km</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>5 km</td>
<td>1.6</td>
</tr>
<tr>
<td>Zone 3</td>
<td>5 km (*)</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>10 km</td>
<td>3.3</td>
</tr>
<tr>
<td>Zone 4</td>
<td>10 km (*)</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>20 km</td>
<td>0.95</td>
</tr>
</tbody>
</table>

(*) : doses for the zone limit

The scenario with the evacuation of Zone 3 is also studied. In this scenario, people are expected to be at home near t_l+10 h. They are then asked to evacuate at t_l+11h and should have left the area before t_l+19h. This leads to the doses given in table 5:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Effective dose (mSv)</th>
<th>Thyroid dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adult</td>
<td>1-yr child</td>
</tr>
<tr>
<td>Zone 3</td>
<td>5 km (*)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>10 km</td>
<td>0.82</td>
</tr>
</tbody>
</table>

(*) : doses for the zone limit

The thyroid dose in the first km still remains high, despite the implementation of ST3, which calls for a faster execution of the countermeasures in zone 1. The maximum effective doses
reached in zones 3 and 4 with ST3 are low: at 48 h, 14.4 mSv in zone 3 and 4 mSv in zone 4 for children. With the evacuation of zone 3, effective and thyroid doses will respectively be lower than 3.7 and 38.8 for children and lower than 3 and 16.4 mSv for adults.

6) CONCLUSION
The calculations presented here show that substantial doses reductions can be achieved and provide useful information to judge the efficiency of various strategies of countermeasures. Calculations for other strategies are foreseen. Later on, authorities will be involved to bring in practical inputs addressing the feasibility of the strategies and the choice of the most appropriate actions in the short term of a major nuclear accident.

7) REFERENCES


GIS-DSS FOR RISK MANAGING AND DECISION-MAKING AIDING ON SITE-SPECIFIC REHABILITATION OF RADIOACTIVE CONTAMINATED TERRITORIES

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The large-scale and long-term consequences of contamination of the environment by long-lived radionuclides caused by the Chernobyl accident have required the elaboration of new approaches and methods for the estimation of the post-accident situation and the choice of appropriate intervention measures. In the 80-90's a number of models and computer systems for the estimation of consequences of a nuclear accident had been developed. Among them, the RODOS system/project should be noted here first of all, as well as computer systems developed in Russia: RECASS and IBRAE bank of models [1].

However, process of using computer decision support systems (DSSs) when making decisions on site-specific CMs for protection of the population and rehabilitation of contaminated territories in Russia (and in the former USSR as well) is unsatisfactory. And it is not caused by unwillingness of decision makers/experts, which are directly involved in that process, to implement DSSs in their practical work. It is caused, in particular, by that the most of computer systems developed are intended for analysing the consequences in the first (acute) period of liquidating the consequences of an accident, for the control of a local source term, or have information character. Some models are intended only for the analysis of specific problems (migration of radionuclides in soil, dose estimation, etc.). In addition, existing computer systems can be used for separate assessments and some research, but not meet the demands for practical site-specific implementation (and they are also too big/complicated and unadapted to the use by specialists in their practical work on the level of a district, farm or settlement).

PRANA DSS. The PRANA is a decision support system on countermeasure management in agriculture in the long-term period of liquidating the consequences of a nuclear accident. PRANA DSS is intended, first of all, for solving the following tasks:
- estimating the structure of contamination of agricultural production;
- assessing the results of application of a wide range of countermeasures on decreasing the contamination of agricultural products and population doses;
- evaluations of countermeasure effectiveness with the use of radiological and economic methods;
- comparison of different alternatives/protective strategies (agricultural countermeasures, restrictions on local foodstuff) with the possibility of changing/analysing various intervention levels.

The first version of PRANA was developed within the International Chernobyl Project JSP2 based on the raster GIS. A version of PRANA DSS for practical implementation (based on the vector GIS, and for Novozybkov district of Bryansk region as an example) was developed within the ISTC Project #150 in 1998.

The description of the system, including the structure and features of PRANA and examples of implementation as well, was presented in [2,3].

However, though PRANA(-98) is implemented at the Chernobyl Department (Ministry of Agriculture) and at the Bryansk Centre of Agrochemical Radiology, but its possibilities are
restricted. And PRANA(-98) should be sufficiently extended to meet all the main demands to DSS for practical use and research on rehabilitation of contaminated territories.

NEW VERSIONS OF GIS-DSSS. Research on restoration/rehabilitation of contaminated territories and development of corresponding multistarget GIS-DSSs are carried out within the ISTC project #1224. It is a joint R&D of Russian team (scientists from RRC Kurchatov Institute, OINPE, RRC Institute of Biophysics, IRG/St.-Petersburg, Institute of Civil Defence/Emercom of Russia, Bryansk Centre of Agrochemical Radiology, Chernobyl Department/Ministry of Agriculture and some other institutes) and European collaborators (NRPA, CEPN, GSF, NRPB, RISO). Within this joint work the significant attention is paid not only to creating up-to-date GIS-DSSs, but also to developing original mathematical models and realising complex research and estimations. It is necessary to point out the works within this ISTC project do not reiterate and are considerably different from the works in Russia and abroad on creation of computer systems for estimating the consequences of a nuclear accident. And prototypes of GIS-DSSs developed and being developed are fully complementary to the RODOS, IBRAE DSS, EDSS and other systems. Conceptual requirements to the computer systems were elaborated in contacts with interested parties: Ministry of Agriculture, Minatom, Emercom, Ministry of Health, Ministry of Science, Administration of Bryansk region.

Realisation of the planned requirements and tasks achieves not through development the only universal/multistarget system, but through creation of several GIS-DSSs (new PRANA versions, though all of them are considerably different from PRANA(-98) and each of them is intended for analysis of specified range of problems):

- GIS-DSS for practical implementation;
- GIS-DSS for research and for scientific and practical estimations;
- GIS-DSS for training of the specialists;
- GIS-DSS as well as computer realisation of thematic blocks for implementation as lectures, seminars and tests/questionnaires for aims of education (students, specialists);
- elements of distributed systems and remote access to components of GIS-DSS (for practical use, training and education).

The conditional “5th level” represents a compilation of levels indicated above for purposes of creation of remote access and distributed systems based on the implementation of Internet-technologies.

Specified GIS-DSSs are intended for investigation of a wide range of tasks/scenarios in the long-term period after a nuclear accident. They comprise all key aspects of complex evaluation (with the use of radiological, ecological and socio-economic factors) of a radiation accident, protection of the population and rehabilitation of contaminated territories. The indicated levels apply to the same problems (consequences and rehabilitation), but have fundamental distinctions outgoing from their purposes, that should become apparent in the functional possibilities, types and amount of information presented for user and ways of presentation input/output and other information as well.

The following sections/blocks, which are realised in accordance with the chosen level of the system, represent in the aggregate a basis of each GIS-DSS indicated above:

- databases (radioecological, economic, demographic and other monitoring and/or simulated data, as well as various parameters, standard and other values);
- libraries of electronic maps (including different layers of vector maps of landuse for territories under consideration);
• spatial analysis of various data from databases, including spatial analysis of radioactive contamination;
• contamination of agricultural production (plant growing and animal husbandry, including farm and private production);
• external and internal doses to the population for radionuclides under consideration (for each settlement of region under consideration, including site-specific aspects of behaviour, food-basket forming and contamination of farm, private and forest production);
• radiological risks caused by irradiation of the population;
• protective measures (CMs) in the long-term period after an accident and estimation of results of their implementation;
• multi-criteria assessment of CMs effectiveness;
• implementation of radiation protection principles (as well as existing requirements of international and national standards and legal regulations);
• support of decision making on protection of the population and rehabilitation of radioactive contaminated territories.

Computer systems for education and training maintain additional sections/blocks: glossaries, lecture and seminar courses and tests/questionnaires as well. As a rule, databases (associated with electronic maps) in those systems are simulated, and mathematical models are presented by simplified versions, except for a version for training specialists, which are directly involved in decision making on rehabilitation of contaminated areas.

In GIS-DSS for practical implementation databases with real data/maps are used (including data for all (six) contaminated districts of Bryansk region) along with the main and maximum adequate models. At that, inclusion of some model (and corresponding computer module from developed libraries) in the given version of the system depends on the goals of its implementation and users. It means development of different versions of GIS-DSS for their use at corresponding departments of Ministries indicated, as well as at corresponding departments at regional, district, settlement and farm administrations.

In GIS-DSS for research and carrying out scientific and practical estimations databases with real data along with all models/modules from developed libraries are used. In contrast to other systems, GIS-DSS for research includes several original models intended for research and (extended) scientific and practical assessments. E.g., only within the framework of this system:
- multi-criteria (dynamic) algorithms for optimisation of countermeasure structure with consideration of radiological, economic, ecological and social factors and restrictions,
- multi-level adaptive and stochastic dose and risk models,
- analysis of uncertainties for all main calculated values (from contamination of agricultural produce up to dose and risk assessments before or after countermeasure implementation), as well as
- specific models for research (analysis of fluxes, vulnerable areas, zoning and ranking, indirect CMs, decision making and uncertainty analysis, etc.)

are used.

Development of libraries of computer modules which realise the models, means of access, interface and other service functions is based on the principles of system and object oriented approach, that allows to create effectively applications appropriate for the chosen level of the system from modules of developed libraries.
CONCLUSION. PRANA DSS and extended versions of PRANA discussed above are up-to-date geoinformation decision support systems. They are intended and can be used for analysing a wide range of problems on rehabilitation of radioactive contaminated territories. One of the features of PRANA DSSs is the use of the most detailed (vector) electronic maps of landuse, which allows realising the site-specific analysis of problems mentioned for different levels of estimation and decision making (from field and settlement levels up to farm, district and regional levels). At present PRANA(-98) is used for support of monitoring network in agriculture and analysis of agricultural countermeasures. After extended discussions, verification, testing and improvement indicated computer systems will be introduced at the corresponding Departments at Ministry of Agriculture, Emercom, Minatom and Bryansk administration (for decision making support on rehabilitation of contamination territories in Russia and training), as well as at some research and academic Institutes/Centres (for research, education and training).

ACKNOWLEDGEMENT. The indicated work is carried out under ISTC project #1224. We are grateful to all our colleagues – project participants and collaborators – for their irreplaceable input in the work on elaboration and development of PRANA DSSs.

REFERENCES


SELF-RATED RISK OF RELOCATION

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The questioning of 60 relocated was fulfilled in Russia in the framework of the JSP-2 project 9 years after Chernobyl Accident. The average quantity of subjective radiation risk evaluation was higher then evaluation of the risk of relocation. There wasn’t any person, who have perceived the Chernobyl risk as “not danger at all” and only 7 respondents have had opinion that relocation was “not danger at all”.

Nevertheless, Chernobyl risk was evaluated as “danger” and “very danger” for health by 43% of relocated peoples. Risk of relocation was evaluated the same by the 45% of them. Years after Chernobyl Accident and after relocation only 10 persons (17%) thought, that the relocation was obligatory action and they decided to relocate even they knew all the difficulties due to relocation.

All relocated peoples indicated the absence of the mutual understanding and aid from the local government bodies was the most difficult part of their life after relocation. There wasn’t any aggression against the relocated peoples from the native, but some of the local peoples called them “nabrody”. The meaning of this new word was “those, who come by food, who don’t know where they have come, who were as vagrant”.

Relocated peoples need in medical care (78%), economical support (42%), better food for childrens (35%). The only personal benefit of relocation was the personal sense of better health after relocation.

The most important conclusion of this questioning study was that relocation must have the radiation-hygiene substantiation (prognosis of cumulative doses of radiation) first of all. The next reason of relocation must be the psychological condition (for example, subjective radiation risk evaluation). Social and economical substantiation (like absence of the supplementary support for peoples on contaminated territories) occupied the next place for relocation reasons ordering.
LIFESTYLES OF PEOPLE THAT LIVE IN THE CHERNOBYL ZONE OF NUCLEAR POLLUTION

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Lifestyle could be viewed as an integrative indicator of personality adaptation to the harmful conditions of natural environment. Studying lifestyles of people living in zones with different severity of nuclear pollution makes it possible to understand the reasons underlying social risks and develop strategies for coping with them.

Our study was conducted during 1990-1998. All over this time we paid particular attention to such indicators of coping as health-worry, social interactions, life-attitudes, prevailing moods and others.

The results of the study showed that the most palpable influence of Chernobyl catastrophe is seen in cases when people are living in severely polluted areas. This influence could also be seen in cases when people get serious compensation for living in such polluted zones.

The factor of radiation is conciously initiated by the means of ecopsychological attitudes though there is no simple relation between determinants and results. There are also a number of other factors which need to be considered in order to reach more or less adequate understanding.
ABSTRACT

«The research shows, that normal functioning of the genetic program in each individual is the guarantee of the population health. Mutations often lead to worsening of health, deformity, decreased activity of the nervous system, immunodeficiency, cancers, reduction of the life time. Mutations can affect all aspects of the vital functions of man at all ages, from a fecundated ovule to death... Very dangerous are radiation damages of heredity. Their long-term threat has become especially evident after the explosion of reactor on Chernobyl nuclear power plant (NPP) in April of 1986...» (Dubinin, 1994).

Modern methods of molecular genetics, biology and biotechnology make it possible to perform the preventive pre-morbid diagnostics of radiation-induced mutation changes and can ensure genetic therapy. To solve the abovementioned problems, it is necessary to organize International (World) Center with all latest equipment located in the climatically geographically most favorable region for rehabilitation of the radiation-affected peoples. The base for the organization of a World rehabilitation Center may be the Israelis Immigrants’ Health Center created by one of the co-authors of present paper (Dr. S. Shapiro) which has already started its practical activity. The Center helps people who have arrived from Chernobyl «zones». The Center have contacts with WHO (World Health Organization), the Ministries of Health in Russia, Ukraine, Belarus. The main strategical direction must be the minimization of mutagen risks ensured on a high professional level not only to individuals, who have suffered from the Chernobyl disaster, but for all persons from various countries subjected to as accidental, occasional and occupational radiation exposure.

The radiation risk in the modern world increases both for an individual person and for the mankind as a whole. Tens of millions peoples in various countries of the world are affected by the chronic influence of small doses (to 10-25 cSv). This process has expanded and intensified especially after the Chernobyl disaster that happened in the former USSR 26 April 1986. According to various estimations, the total Chernobyl effluent into the environment is in the range from 50 millions to one milliard and more [1,3].

The genome effects for exposed people (our contemporaries) and genetic consequences for their children are most dangerous [1,2,7], because the two classical phenomena have been established by radiobiology:

1) the absence of minimal threshold doses;
2) the enhancement (intensification) of radiation-genetic effects in somatic cells of the organism on the reduplicational mechanism (N. V. Timofeev-Ressovsky).

How to maintain the stability of genome for our contemporaries and the genetic fund of the mankind?
How to protect children from the increasing mutagenic risk of radiation and chemical influences, involving inevitable and irreversible consequences?

The answer these difficult questions may be based, on deep persuasion of the authors of present report, only on the way of creation of the World (International) scientific-practical Rehabilitation Center for persons,Exposed to Radiation. A single country, even a highly developed one, can not solve these problems separately to day.

The strategy of creation of such a Center must become the international scientific and practical collaboration on the problem of minimization of the genotoxical risk for the contemporaries and future generations, affected to small doses of exposure, consequences of the Chernobyl and other nuclear disasters possible in future (4,5). The present National Centers of various countries (Israel, Belarus, Ukraine, Russia) on the radiation medicine are working as a rule with the already fallen ill persons, where as it's necessary to prevent the development of illnesses. It shows the necessity of forming the new basic principles of its activity:

I. The express-diagnostics of functional state of the systems and organs of suffered persons with help of the modern computer-electronic methods and forming of appropriate national registers (data bases) on these people.

II. The differentiated diagnostics of the radiation- and chemical-induced effects, the estimation of accumulated in organism pre-morbid (pre-clinical) disgenome, disimmune, disgормonal, disenzyme changes in the REGIME OF OUTSTRIPPING with a purpose of analysis of the molecular-cellular risk as for a health of single person as for the large groups of population living in the similar conditions.

III. The timely acceptance of individual rehabilitation and preventive measures (antimutagens, antioxidants, sorbents, stimulators of DNA-reparation and cellular regeneration, immunomodulators) with a purpose of minimization of the mutagenic risks of development for the various forms of pathology ( syndromes of chronic weariness, second immune insufficiency, accelerated aging, violation of reproductive functions, the chronic inflammatory illnesses and degenerative processes, allergic and asthmatic reactions, neo-morphology manifestations (cancers, leukoses), for offspring’s - hereditary illnesses and innate vices of development).

For realization of the abovementioned principles it’s necessary to create the International (World) Center, equipped by most modern devices, placed in climatically and geographically most favorable region for rehabilitation of people, affected to radiation influence. The All-Israelis Immigration’s Health Center, created by one of the co-authors of the present report (M.D. S. Shapiro), which have began its practical activity already, may be considered as the basis for organization of the World Center of rehabilitation. The Center basing oneself up on the achievements of Israelis and World medical science, helps to people, who have arrived from Chernobyl zones of Russia, Ukraine and Belarus. The Center has close connections with the World Health Organization (WHO), the Ministries of Health of these countries, their profile Centers and Institutes and it develops successfully its scientific and practical activity (5).
The problem of the creation of World Center for rehabilitation of persons, suffered from radiation influences - this is a problem of present and future health for our children. This problem can not wait. The struggle for Life hasn't alternatives!

ACKNOWLEDGMENT
The authors are grateful to their colleagues from «Immigrant’s Health Center» (Haifa, Israel) for useful discussions of the problem of creation of World (International) Rehabilitation Center for Suffered from Radiation Influences.

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Risk Analysis: Facing the New Millennium

For realization of the above-stated principles it’s necessary to create the International (World) Center, equipped by most modern devices, located in climatically and geographically most favorable region for rehabilitation of people, affected to radiation influence. The Armenian Immigration’s Health Center, created by one of the directors of the present report (M.D. K. Grigorian), which have begun its practical activity already, may be considered as the basis for organization of the World Center of rehabilitation. The Center, having scientific as well as the administrative of Israeli and World medical science, helps to people, who have arrived from Chernobyl zones of Ukraine, Lithuania and Belarus. The Center has close collaborations with the World Health Organization (WHO), the Ministry of Health, of these republics, their profile Centers and Universities and it develops successfully its scientific and practical activity.
TRACK 5

SESSION 4

FOOD/HEALTH RISK
A QUANTITATIVE RISK ASSESSMENT FOR CAMPYLOBACTERS IN BROILERS: WORK IN PROGRESS

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Campylobacters are the commonest cause of human acute bacterial enteritis in the UK and during the period 1988 to 1998 numbers of reported cases increased from 28 thousand to 58 thousand. Communication with the Communicable Disease Surveillance Centre indicates that this is a gross under estimate as many cases go unreported. Infection with campylobacters results in high human and economic costs and has been linked in epidemiological investigations with the consumption of poultry meat. A quantitative risk assessment is being formulated to estimate the risks of human infection with campylobacter from the consumption of broiler/broiler products. All stages in the poultry supply chain are of significance in relation to campylobacter contamination in poultry; therefore the risk assessment will be constructed in a 'farm-to-fork' manner. The probability of the organisms being present and at what concentrations will be estimated at each stage of the supply chain. This paper presents the preliminary results for the first stage of the assessment "rearing and transport". This stage considers the situation on the broiler rearing farm and the factors that affect the campylobacter status of a chicken on the farm. Transport from the farm to the slaughter facility is then examined and it's effect on campylobacter in birds evaluated. The outputs for this module are the probability of a random bird being campylobacter positive at the point of slaughter and the likely microbial load a positive bird will carry.
APPLYING QUANTITATIVE RISK ANALYSIS TO VETERINARY DECISIONS IN THE DANISH POULTRY INDUSTRY: VACCINATION VERSUS STAMPING OUT

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ABSTRACT
The application of Quantitative risk analysis (QRA) to veterinary decisions on whether to vaccinate or stamp out, is presented and discussed as a new field of application for QRA.

INTRODUCTION
Traditionally, quantitative risk analysis (QRA) deals with evaluating potential risks for human lives and well-being. For over twenty years now, risk analysis has been applied to evaluate possible risks for humans associated with nuclear and chemical industries. Fairly recently, QRA has been applied to the veterinary field to highlight possible risks associated with human health in connection with food-borne hazards (Bemrah, 1998) and risks of introducing animal diseases into a country through importation of live animals or animal products (Sutmoller, 1995). However, a largely unexplored potential of QRA also exists for evaluating veterinary strategies in order to deal effectively with animal diseases. Denmark is currently faced with a veterinary decision within the field of poultry production. The choice stands between two different strategies towards Newcastle disease (ND). ND is an animal disease, which affects poultry. It is currently regulated through EU Council Directive 92/66/EEC, because it has the potential to cause major economic impact on European poultry production. Denmark has experienced outbreaks of ND in 1972, 1995, 1996 and 1998. The outbreaks have been costly to the Danish State and the poultry producers, who have experienced outbreaks, but also poultry producers situated within the protection- and surveillance zones laid down according to the EU Council Directive, have experienced considerable economic losses. In Europe today, only the Scandinavian countries and Switzerland pursue a stamping out strategy towards ND. Other European countries control ND through vaccination. The situation regarding ND was similar in Denmark and Ireland until 1997, when Ireland started vaccinating. A debate has started in Denmark, whether to follow the Irish example or not. QRA represents a possible tool to form a basis for such a decision. Using simulation modelling, the risks associated with introducing ND-vaccination in Denmark may be compared to the present situation, and the consequences measured in economic costs as well as benefits may be calculated. The application of QRA on the decision vaccination versus stamping out will be discussed and preliminary results presented.
MATERIALS AND METHODS

Denmark has an annual production of 112 million broilers. Every year 120,000 broiler parents are imported mainly from the United Kingdom and allocated to four Danish hatcheries, which supply 350 broiler producers with day-old broiler-chickens. Because of this hierarchical structure of the poultry production, the by far largest consequences of a ND-outbreak in Denmark, would occur if ND were introduced into one of the four broiler-hatcheries.

In 1993 the EU-Commission supplied the European Council with a report concerning the risk of transmitting Newcastle disease (EU-Commission, 1993). This report was based on the work of a subgroup formed by the Scientific Veterinary Committee. The results were unanimously accepted by the Scientific Veterinary Committee before they were passed on to the European Commission. The risks of introducing ND into a country were evaluated as stated in table 1.

Table 1.
Evaluation of the risks of transmitting ND into a country from different sources.

<table>
<thead>
<tr>
<th>SOURCE OF INFECTION</th>
<th>RISK OF TRANSMITTING ND INTO A COUNTRY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Exotic birds</td>
<td>High risk.</td>
</tr>
<tr>
<td>2. Wild birds</td>
<td>Moderate risk for poultry located under migratory paths</td>
</tr>
<tr>
<td>3. Pigeons</td>
<td>At the moment (1993) high risk if they have access to poultry feed, or have contact with free-ranging poultry.</td>
</tr>
<tr>
<td>5. Reptiles and scavengers</td>
<td>Low risk.</td>
</tr>
<tr>
<td>4. Live poultry and hatching eggs</td>
<td>Variable risk (low to high) for live poultry depending on the control measures taken by the exporting country and the transportation. Low risk within the EU, if control-measures are implemented. Low risk for hatching eggs provided they correctly disinfected.</td>
</tr>
<tr>
<td>6. Feed</td>
<td>Variable risk (low to high) depending on the origin of the feed, storage, treatment and particularly heat-treatment.</td>
</tr>
<tr>
<td>7. People</td>
<td>Moderate risk, which can be lowered by bio-security at farm-level</td>
</tr>
<tr>
<td>8. Air and water</td>
<td>Low risk.</td>
</tr>
<tr>
<td>9. Infected equipment</td>
<td>Normally low, but high risk can be present in cases where infected vehicles cross borders to countries where ND is common.</td>
</tr>
<tr>
<td>10. Fertilisers with poultry manure</td>
<td>High risk, unless treated properly.</td>
</tr>
<tr>
<td>11. Eggs, poultrymeat, &amp; products</td>
<td>Low risk within the EU, if control-measures are implemented.</td>
</tr>
<tr>
<td>12. Vaccines</td>
<td>Low risk if used according to EU-recommendations.</td>
</tr>
</tbody>
</table>
The risks stated in table 1, must be re-evaluated from a Danish perspective and subsequently quantified before applied to a QRA model. Our aim was to estimate by simulation the annual risk of ND outbreaks in Danish broiler hatcheries and Danish broiler flocks, and to calculate their economical consequences. An outline of the QRA model was presented in figure 1.

Once the birds have been vaccinated against ND, the risk of them becoming ill from the ND-virus is lowered considerably. They can however, still carry the virus and pass it on to susceptible birds, without showing any sign of illness themselves. Today, Danish parent birds to the broiler production are tested for ND before they start producing hatching eggs. Once they have entered the egg-production period, no testing for ND is performed, unless the birds become clinically ill. The testing before egg-production is done on sixty blood-samples collected at each premise with parent-birds. If the test is positive (ND-virus present), a second test is performed to determine the virulence of the ND-virus. This test is very costly and laborious, and will only be performed, when ND-infection is suspected. If the animals are vaccinated against ND, the initial test, will not be able to distinguish between reactions caused by the ND-vaccine, and reactions caused by a virulent ND-virus. Therefore, after vaccination no routine testing of the parent-birds will be performed.

The crucial question is, by how much does the vaccination and disposal of routine ND-testing of the parent-birds alter the risk of introducing ND into Danish broiler production? Using QRA we analyse the two different scenarios for comparison (see figures 2a and 2b):

A) The risk of ND outbreaks in the Danish broiler production in a situation where ND vaccination is prohibited (present), and

b) the risk of ND outbreaks in the Danish broiler production under a situation where ND vaccination is allowed.
Figure 2.a. Non-vaccination scenario:
Risk of ND outbreaks in the Danish broiler production.

The ND-status of parent birds can assume three different stages: 1) Not ill - ND-virus not present, 2) not ill - ND-virus present and 3) ill - ND-virus present. Birds infected by ND-virus (stages 2 and 3) will be killed, if detected. Note that in the vaccination scenario, it is not possible to detect stage 2. For ND status of the broiler-flocks we distinguish only between two stages: A) Not ill - ND-virus present/absent and B) ill - ND-virus present. For broilers, a possible ND-infection will only be detected if the chickens show signs of clinical disease.

For simulation of the two scenarios, we need assessments of the external probabilities in the diagrams (figures 2a and 2b): Probability of introducing ND into the hatcheries and broiler flocks (figure 1), and probability of importing parent birds in the 3 stages. Furthermore, we need assessments of the probability of transitions, e.g., probability of transmitting virus from not-ill parents to broiler offspring, and also the probability for the ND-status of vaccinated/non-vaccinated parent birds after external risk exposure. All the probabilities, and their uncertainties, may be collected by expert judgement.

Using the same risks for external factors and identical transitions in the two diagrams, we compare the ND-vaccination program for broiler parents to the non-vaccinating strategy, in terms of the costs and the risks of a ND-outbreak. It may be noted that the economic consequences for poultry producers situated within the protection- and surveillance zones laid down according to the EU Council Directive 92/66/EEC, are the same for both veterinary strategies.
DISCUSSION
When evaluating veterinary strategies towards specific diseases, QRA represents an effective tool to compare epidemiological and economic effects of different scenarios. The QRA models provide insight into the impact of uncertain factors on the outcome of the strategies, and elucidate strengths and weaknesses of the applied components. However, use of expert opinion when data is not available, may present a threat to the credibility of the QRA models. The only alternative to this problem is to base the decision on no formal analysis. At least the process of drawing up the model and examining the effect of altering different values within the model provides a transparency to the different strategies, that can only be a benefit for decision makers. Recently simulation modelling has been used to examine five different control strategies towards infectious bovine rhinotracheitis in the Netherlands (Vonk Noordegraaf, 1998). It is our prediction, that QRA has a large future potential for assisting policy-makers in decisions that involve choices between different veterinary strategies.

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ESTIMATION OF THE PREVALENCE OF SALMONELLA INFECTED ANIMALS IN POULTRY FLOCKS AND IMPLICATIONS FOR LOGISTIC SLAUGHTERING

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ABSTRACT
Animal level prevalence $p$ of Salmonella infection may vary between broiler flocks. Pooled sample data from different flocks, in combination with model assumptions, can be used to describe the distribution of $p$. Preliminary results indicate that a model assuming that part of the flocks is not infected and that, for infected flocks, $p$ has one of two possible values satisfies best. Attention was given to the relationship between the sensitivity of the Salmonella test in a pooled sample and the estimation of $p$. Also, the estimation of $p$ allows for an estimation of the fraction of false negative flocks, which is important for the evaluation of the effect of logistic slaughtering as a risk mitigation strategy.

INTRODUCTION
For veterinary or public health purposes, it is important to determine the infection status of broilers for Salmonella. This status is often determined at flock level. For financial reasons relating to sampling and sample investigation, usually not all but a limited number of animals is investigated using a small number of pooled samples. However, the prevalence of infection at animal level is also of interest. For example, within a flock of 25,000 animals, it can make a large difference whether 10 or 10,000 animals are infected. Information on this animal level prevalence can be extracted from pooled sample data if some assumptions are made on the way animal level prevalence varies between flocks.

Previously published methods were aimed at analysing one population with a certain animal/individual level prevalence, or analysing a number of populations separately (see Cowling et al., 1999 for a review). In this paper, a method is described to estimate animal level prevalences from pooled sample data simultaneously for a number of related flocks, taking into account the variation of this prevalence between flocks. A number of different assumptions can be made for this variation.

MODELLING AND STATISTICS
Consider a data set which consist of the testing results of a certain number of flocks. For every flock, $m$ pooled samples are investigated. Of these pooled samples, $x$ are tested positive, where $0 \leq x \leq m$. Each pooled sample consists of $n$ individual samples. First let us consider one arbitrarily chosen flock. A fraction $p$ of the animals is assumed to be infected, so the probability of an individual sample to be positive is equal to $p$. The probability of a pooled sample to be positive, $q$, is equal to 1 minus the probability that all $n$ individual samples that are combined to this pooled sample, are negative. So (Hauck, 1991):

$$q = 1 - (1 - p)^n$$  \hspace{1cm} (1)

For this flock, the number of positive pooled samples $x$ out of the total number $m$, is binomially distributed:
\[ P(x | p) = \binom{m}{x} q^x (1 - q)^{m-x} = \binom{m}{x} (1 - (1 - p)^n)^x (1 - p)^{n(m-x)} \]  
\[(2)\]

with \(P(\cdot)\) the probability.

For the variation of the fraction of infected animals \(p\) between flocks, a number of simplifying assumptions can be made. Below, four possible models are given describing the variation in \(p\). These are characterised by a limited number of parameters, which is important to allow for model fitting to a data set. Note that a flock is considered infected if one or more of the animals of this flock is infected. The models are defined as follows:

1. All flocks are infected and in all flocks the same fraction \(p\) of animals is infected (1 parameter).
2. A part of the flocks is not infected. In all infected flocks the same fraction \(p\) of animals is infected (2 parameters).
3. A part of the flocks is not infected. For the infected flocks, the animal level prevalence \(p\) varies between flocks. This variation is described by a Beta distribution. This distribution is chosen as it is defined for the interval (0,1) and because its shape is very flexible (3 parameters).
4. A part of the flocks is not infected. The infected flocks are divided into two types. All flocks belonging to one type have the same animal level prevalence \(p\). Therefore all infected flocks have one of two possible values for the animal level prevalence \(p\) (4 parameters).

The values of model parameters can be estimated using the method of maximum likelihood (Mood et al., 1974). It can be statistically tested whether one model fits better than another by a likelihood ratio test. Precondition for this test is, that the models that are compared are hierarchical, that is the model next in the hierarchy reduces to the previous one by omitting one or more parameters.

Above, it has been implicitly assumed that the sensitivity of the test for Salmonella is 100 %, or in other words, the probability that a micro-organism is detected in a pooled sample given that it is present, is equal to 1. In fact, one has to consider two steps:

- the probability that a pooled sample contains Salmonella;
- the probability that a pooled sample containing Salmonella gives a positive test result.

This can be modelled by stating (Tu et al., 1994):

\[ q = q_{act} s \]
\[(3)\]

with \(q_{act}\) the probability that a pooled sample contains Salmonella, \(s\) the sensitivity and \(q\) the probability that a pooled sample gives a positive test result.

An important spin-off of the estimation of animal level prevalence \(p\) is that, given the number of sampled animals, \(nm\), the probability of a false negative flock can be calculated. A false negative flock is an infected flock that is erroneously considered uninfected. The probability of a false negative flock is equal to the probability that all sampled animals in an infected flock were by chance uninfected.
RESULTS AND DISCUSSION
The reduction of costs as achieved by pooling samples, seems obvious as one saves on laboratory materials and labour. Some authors state that cost reduction is not so univocal as one would think at first sight. Behets et al. (1990) for instance, state that cost-efficiency only improves when the seroprevalence and/or the marginal cost of obtaining a sample are sufficiently low. Therefore the decision to pool samples must be backed up by a financial analysis which takes these variables into account.

The great majority of literature on pooled samples deals with HIV seroprevalence in human populations. In this field, seroprevalence testing is performed on large populations. If the seroprevalence of a human population is to be estimated, model 1 is sufficient. This background probably explains why all literature known to the authors that deals with pooled samples uses model 1 as a starting point. In contrast, the present paper deals with the simultaneous description of a number of flocks that may differ in animal level prevalence.

Preliminary results of application of the four models to pooled sample broiler flock data on Salmonella spec. and Salmonella serotypes yielded the following results. Model 1 gives a relatively very poor fit compared to model 2, rejecting the hypothesis that all flocks are infected. Model 3 and 4 give a better fit than model 2, which indicates that, in general, the assumption of a constant animal level prevalence \( p \) in infected flocks is not correct. The fit of model 3 and 4 cannot be statistically compared as they are not hierarchically related. Depending on the exact shape of the fitted Beta distribution, model 3 can give conceptual problems (see next section). Therefore in general model 4 satisfies best.

In the models, \( p \) is interpreted as the actual animal level prevalence in an infected flock. Actually, it should be interpreted as the probability of an individual animal to be infected. But in case of large flocks the last definition is equal to and reduces to the first one. For small flocks and/or at low animal level prevalence \( p \) it should be taken into consideration that flocks consist of individual animals. The animal level prevalence then becomes a distribution \( \text{Bin}(N_i p)/N_i \) with \( N_i \) the size of flock \( i \) and \( \text{Bin}(\cdot) \) a binomial distribution. This model extension also affects the prevalence at flock level. “Infected” flocks for which \( N_i p < 1 \) are in reality partly uninfected. The probability for non-infection is equal to \( \text{Bin}(0)/N_i \). This aspect is particularly relevant in case of a Beta distributed \( p \), as the Beta distribution by definition ranges from 0 to 1. The Beta distribution thus always includes small values for \( p \), but its data fitted shape determines whether this can be neglected. If not, \( p \) should be replaced by \( \text{Bin}(N_i p)/N_i \), resulting in a Betabinomial distribution (McCullagh and Nelder, 1989) divided by \( N_i \).

The effect of sensitivity \( s \) was investigated using model 2. The following conclusions can be drawn:

- As expected, the animal level prevalence \( p \) increases as sensitivity \( s \) decreases. If for the same data a lower sensitivity is assumed, a higher \( p \) is necessary to explain these data;
- The shape of the curve describing the relationship between \( p \) and \( s \) is only affected by the value of \( n \);
- If \( s = 1 \), \( p \) has its minimum possible value. In that case, all negative pooled samples from infected flocks are due to Salmonella really not being present, which is caused by not all animals being infected;
- If \( p = 1 \), all animals in an infected flock are infected and all non-detected Salmonella infection is due to the sensitivity \( s \) of the Salmonella test which then has its minimum value;
The prevalence at flock level does not change as a function of sensitivity $s$.

Estimation of the fraction false negative flocks can be of importance for risk management of *Salmonella* in the poultry meat production chain. In the Netherlands, the poultry meat sector is currently attempting to reduce *Salmonella* infection levels. One option to achieve this is implementation of logistic slaughtering in slaughterhouses. During conventional slaughtering, flocks are slaughtered in random order. As a result of this procedure, there is a risk that originally uninfected flocks become contaminated if they are slaughtered after an infected flock. This would lead to an increase in flock level prevalence through slaughter. During logistic slaughter, the slaughter order of flocks is adjusted, so that uninfected flocks are slaughtered first and infected flocks last. Ideally (or theoretically), this would result in flock level prevalence before and after slaughter being equal. The positive effect of logistic slaughter is being thwarted by false negative flocks, that are put in front in the slaughter row and might contaminate uninfected flocks. As explained above, estimation of animal level prevalence allows for an estimation of the fraction of false negative flocks. This information is essential for estimating the true reduction of flock level prevalence after slaughter that is realised by replacing conventional by logistic slaughter. This reduction is less than in the theoretical situation without false negative flocks. This is important for assessing the effect of logistic slaughtering as a risk mitigation strategy.

**ACKNOWLEDGEMENTS**

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**REFERENCES**


"FARM TO FORK" EXPOSURE ASSESSMENT: MODELLING THE PROCESS

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ABSTRACT
"Farm to fork" exposure assessment is popular in quantitative microbial risk assessment (QMRA). In some recently published studies the transformation of data to probability distributions to be used in Monte Carlo simulations receives much attention. However, a general approach to modelling the transmission of a microbial hazard in a “farm to fork” risk assessment has not yet been accomplished. Here, the development of a framework is proposed, that can be used to create a unified methodology for “farm to fork” exposure assessment. Five basic processes for QMRA are identified, which can be combined to describe any “farm to fork” process. The modelling of bacterial growth is used to illustrate some of the specific aspects that should be incorporated in the models that describe these basic processes. A simple example shows that both uncertainty and variability are relevant and that a separation of these two may be essential in QMRA.

INTRODUCTION
In quantitative microbial risk assessment (QMRA), “farm to fork” exposure assessment is a common goal. Studies on for example S. Enteritidis in eggs, E. coli O157:H7 in beef, L. monocytogenes in cheese, and Salmonella spp. and Campylobacter spp. in poultry are in progress or have recently been published (e.g. Cassin et al. 1998, Bemrah et al. 1998). In these studies the transmission of the pathogen is modelled over some of the consecutive stages of the production process: from farm, via industry and retailer, to the consumer. This production process may be complex and variable, and often the data needed for a QMRA are scarce or only available in an inappropriate format. To deal with the latter, most QMRA studies published so far are concentrating on the transformation of data to probability distributions of model parameters that are to be used for the assessment. This is important for a realistic risk assessment. Unfortunately however, the general approach of the QMRA model and the specific interpretation of the resulting probability distributions gets little attention.

This paper focuses on this general approach and the interpretation of probability distributions as variable and/or uncertain. In the general approach we identify some basic processes. Once the appropriate modelling techniques for these processes have been listed, any “farm to fork” food production process can be modelled as a combination of basic processes. In the models to be used for these basic processes, special attention will be given to the separation of variability and uncertainty. This separation is omitted in a recently published general framework for QMRA (McNab 1998) and the recently published studies mentioned above. By a simple example, involving the growth of B. cereus in pasteurised milk, we will illustrate that neglecting the difference between uncertainty and variability may lead to an improper risk estimate.

MODELLING THE BASIC PROCESSES
In a “farm to fork” QMRA model the transmission of a microbial hazard through the production process is described by the prevalence (the fraction of contaminated units of the
product) and the (distribution of the) number of living cells in the contaminated units. To provide a general framework for “farm to fork” exposure assessment, we identify five basic processes: two microbial processes (growth and inactivation) and three product handling processes (mixing, partitioning and cross contamination). These basic processes all influence the prevalence and/or the number of microorganisms in the product and can be modelled separately. As shown in the table below, the basic processes each have a typical effect on the prevalence ($P$) of microorganisms and their number ($N$): increase (+), decrease (-), or no change (=).

<table>
<thead>
<tr>
<th>basic process</th>
<th>effect on $P$</th>
<th>effect on $N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>growth</td>
<td>=</td>
<td>+</td>
</tr>
<tr>
<td>inactivation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>mixing</td>
<td>+</td>
<td>=</td>
</tr>
<tr>
<td>partitioning</td>
<td>-</td>
<td>=</td>
</tr>
<tr>
<td>cross-contamination</td>
<td>+</td>
<td>- / +</td>
</tr>
</tbody>
</table>

For each of these basic processes, general models have to be built, that describe the changes in $N$ and/or $P$ as a function of some process parameters. Next, any transmission process of a microbial hazard through a “farm to fork” production process can be modelled as a series of consecutive basic processes. By linking the (distributions of the) inputs and outputs of these basic models, any “farm to fork” process can be described quantitatively. An overall stochastic model of the whole transmission process can be built by assembling these basic models.

Several models are available for the basic microbial processes (e.g. Van Gerwen and Zwietering 1998). However, as explained below, these predictive microbiology models are not particularly suited for QMRA. The product handling processes have been modelled in QMRA studies, but to the best of our knowledge a comparative overview is not available. A study on this topic is currently in progress (Evers and Nauta, unpublished).

MODELLING GROWTH IN A QMRA

The type of basic model necessary for a QMRA will be illustrated by modelling the basic process that is most typical for microbial risk assessment: bacterial growth. Although different predictive growth models exist, none of them has been developed for the purpose of quantitative risk analysis. Traditionally, these predictive microbiology models produce point estimates in which uncertainty and variability in growth are not included. Some computer programs like the Pathogen Modeling Program (USDA, 1998) give a ‘confidence interval’, but do not separate uncertainty and variability. We define ‘uncertainty’ as the ‘lack of knowledge’, which may be reduced by gathering additional information. ‘Variability’ is the inherent randomness of the system studied, and can not be reduced by additional experiments or observations. Although the relevance to QRA of the separation of these two in so-called ‘second order’ risk analysis models is well known (Hattis and Burmaster 1994, Rai et al. 1996), it usually is not applied in “Farm to Fork” QMRA’s. Microbial growth models describe the increase in the number of cells over time. Models are available at several levels, with an increasing number of parameters representing growth conditions and growth characteristics that affect growth (e.g. Van Gerwen and Zwietering,
Here we give an example, using an extremely simple (exponential) growth model, to illustrate the relevance of the separation of variability and uncertainty:

\[ \log(N_f) = \log(N_0) + c, \]

where \( N_0 \) is the initial number of cells, \( N_f \) is the final number of cells and \( c \) is an increase parameter.

**EXAMPLE**

As an example, consider the following problem: From a vat with 100 litre pasteurised milk, stored below 4°C, ten samples of 10 ml are taken and tested for the presence of \( B. \) cereus. One of the ten samples is tested positive with a test that has 100% sensitivity and 100% specificity. From this vat 100 cups containing 0.25 l. milk are taken and stored together at about 10°C. After (exactly) 3 days of storage hundred people each drink one of the cups of milk. What is the exposure of these people?

Using the information given in the problem description and data from literature on the growth of \( B. \) cereus in pasteurised milk (see Notermans et al. 1998), probability distributions for \( N_0 \) and \( c \) can be derived. The resulting distribution of \( N_f \), the final numbers of cells in the 100 cups can be found with Monte Carlo simulations.

The probability distributions for \( N_0 \) and \( c \) will express both uncertainty and variability. The initial number of cells in a cup \( (N_0) \), is uncertain because the initial number of cells in the vat is uncertain, and variable because the cups will initially contain unequal numbers of cells. The actual growth, as expressed by \( c \), will be unpredictable to some extent, partially because it will differ per cup (variability) and partially because it is unknown (uncertainty). This uncertainty and variability can be separated by splitting up the probability distributions of the parameters, using second order modelling techniques (e.g. in @Risk).

As illustrated in Fig. 1, independent runs of Monte Carlo simulations show similar results when uncertainty and variability are not separated. If, however, this separation is implemented, the differences between the runs get larger. With increasing uncertainty, the probability that more than 50 people ingest large numbers of \( B. \) cereus cells increases, whereas this probability is negligible if the distinction between variability and uncertainty is not incorporated in the analysis. (This can be seen from Fig 1. by noting that the number of cups with more than \( \log(N_f) = 5 \) cells is always lower than 50 at left, but may be larger than 50 at the right.) Hence, an improper impact on public health may be predicted if variability and uncertainty are not separated.
Fig 1. The results of 10 runs of a Monte Carlo simulation for a series of 100 cups of milk. The distribution of log(N_t), the logarithm of the final number of cells in the cups, is given for each run by an individual line. The indicated numbers on the x-axis are upper limits of classes. Individual lines show the variability between cups, whereas differences between lines indicate the uncertainty. (no sep): the results when uncertainty and variability are not separated. (sep): variability and uncertainty are separated.

DISCUSSION
Above, the outline is presented for a general framework for quantitative microbial risk assessment. In this framework, models will be made for five basic processes for the specific purpose of QMRA. These models will allow treatment of both uncertainty and variability in model parameters. In a simple example on bacterial growth modelling using probability distributions of the model parameters, it has been illustrated that neglecting the difference between variability and uncertainty may underestimate the uncertainty of the risk estimate and consequently lead to an improper evaluation of risk.

REFERENCES
OUTLINE OF A SIMULATION MODEL TO ESTIMATE THE RISK OF CONTAGIOUS ANIMAL DISEASE INTRODUCTION INTO DENSELY POPULATED LIVESTOCK AREAS OF THE EUROPEAN UNION

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ABSTRACT

To calculate the risk of introduction of contagious animal diseases into densely populated livestock areas (DPLAs) of the European Union, three steps are proposed: (i) estimate the likelihood of virus introduction, (ii) simulate the spread of virus and (iii) calculate the economic losses. Many areas around the world and several different risk factors contribute to the likelihood of virus introduction into a specific DPLA. All components involved are put together into a simulation model, that will calculate the number of primary outbreaks during a certain time period for each DPLA. Because many of the parameters used in the calculations are uncertain and variable, probability distributions are entered into the model and Monte Carlo simulation is used.

INTRODUCTION

Risk is defined as the measure of the likelihood and magnitude of an adverse event (Ahl et al., 1993). An important risk for the livestock production sector is the possible introduction of a contagious animal disease into an area hitherto free of the disease and its epidemiological and economical consequences. Classical swine fever (CSF) and foot-and-mouth disease (FMD) are contagious animal diseases which can spread rapidly under such circumstances and may have devastating effects not only for the infected farms, but also for other partners in the livestock chain and the national economy. The impact of these diseases is expected to be positively related with the density of farms and animals in the affected area.

In the European Union (EU) so-called densely populated livestock areas (DPLAs) can be distinguished, that have a high concentration of livestock farms, cattle, pigs, sheep and goats. Economic factors such as the availability of feeding stuff, reasonably priced land, and local consumer demand have led to the development of these areas (Dijkhuizen and Davies, 1995). Economies of scale play an important part in maintaining these areas and attracting even more farms. Recent outbreaks have, however, shown the vulnerability of DPLAs to the introduction of highly contagious diseases, the 1997/98 CSF-epidemic in the Netherlands (Anonymous, 1998) being a striking example. More insight into the specific causes of virus introduction into DPLAs might help to reduce the risk of future epidemics for these areas. Therefore the risk of introduction of CSF and FMD virus into DPLAs will be calculated, using three steps: (i) estimate the likelihood of virus introduction into a DPLA, (ii) simulate the spread of virus within a DPLA (epidemiological consequences) and (iii) calculate the economic losses of introduction. To estimate the likelihood of virus introduction, a simulation model will be developed, incorporating quantitative risk analysis. The establishment of disease and the size of the resulting epidemic will be estimated using a simulation model for spread of contagious animal diseases (Jalvingh et al., 1999), whereafter the economic impact is calculated with an economic model (Meuwissen et al., 1999). The ultimate goal of this risk analysis is to evaluate measures aimed at the prevention of virus introduction into DPLAs for their...
epidemiological and economical effectiveness. In this paper an outline of the simulation model for introduction is presented and discussed.

**SCOPE AND DEFINITIONS**

To structure the modelling of introduction of CSF and FMD virus, a system is assumed in which many areas are distinguished, covering the whole world. These areas can be DPLAs in the EU, other, less densely populated livestock areas of the EU member states, and third countries. The latter are clustered in semi-continents. The DPLAs for which the risk analysis is conducted are called the target DPLAs.

Each DPLA can be delineated with a (hypothetical) border which separates it from the world surrounding it, the exogenous world (figure 1). Many connections are present, both between entities within the DPLA and between the DPLA and the world surrounding it. These connections represent possible risk factors. Risk factors are defined as the 'vehicles' with which CSF or FMD virus can be transported from one area to another area, enter that area and convey the virus to a susceptible animal in that area. Examples of risk factors are livestock, animal products, swill, livestock trucks and air currents. Introduction of virus is defined as the entrance of the virus into a DPLA from out of the exogenous part of the system. Spread is defined as the dissemination of virus from one entity within the DPLA to another entity within the DPLA.

![Figure 1. Schematic representation of the exogenous and endogenous parts of the system, and the difference between introduction and spread.](image-url)

The simulation model will be built in the programming language Delphi. Monte Carlo simulation will be used to account for the uncertainty and variability inherent to many of the input parameters of the model. Although disease specific input parameters will be used, the general lay out of the simulation model can be used for both CSF and FMD.
GENERAL CALCULATION PROCEDURE IN THE MODEL

Before the calculations are started, the user should indicate one or more of the DPLAs in the model as target DPLA. Thereafter, the model simulates the possible introduction of virus for these target DPLAs, given a certain time horizon.

In figure 2 a general lay out of the calculation procedure in the simulation model for virus introduction into densely populated livestock areas of the European Union.

In figure 2 a general lay out of the calculation procedure in the simulation model is given. Five nested loops can be distinguished: (a) iteration, (b) day, (c) area with an outbreak, (d) target DPLA, and (e) risk factor. On each simulated day, the model first checks for all areas if an outbreak is started or still present. For each area with an outbreak, it is checked whether the virus has already been detected and if control measures have been put in place. If the virus has not been detected yet, virus dissemination is not hampered by control measures and the disease can spread freely. Next, for each target DPLA the risk factors coming from the area with an outbreak are screened to see if any of them carries the virus into the target DPLA and causes a primary outbreak. For this purpose, the risk factors are subdivided into (more uniform) types of risk units. For the risk factor live animals, for instance, the following types of risk units can be distinguished: dairy cattle, beef cattle, veal calves, weaned piglets, fattening pigs, sows, goats and sheep. The definition of one incoming risk unit depends on the type of risk unit involved and is the logical unit in which the risk factors are usually measured, e.g. one animal, one kg of an animal product, etc.
CALCULATIONS FOR THE RISK FACTOR LIVE ANIMALS

The calculation procedure in the inner loop ("repeat for each risk factor") can be demonstrated by the calculations for the risk factor live animals. First, the number of export batches going from the exogenous area with an outbreak to the target DPLA on this particular day is estimated, based on the annual number of animals exported and the weighted average size of livestock trucks used. A Poisson distribution is used to account for variation.

Then for each export batch the total number of animals (n) and the number of infected animals (s) in the export batch is calculated.

\[ n = \text{Discrete}(\{v_i, f_i\}) \]  
where  
\[ v_i = \text{average number of animals being conveyed by livestock truck type } i \]  
\[ f_i = \text{percentage livestock trucks of type } i \]  
\[ s = \text{Binomial}(n, p_i) \]  
where  
\[ p_i = \text{prevalence of disease in phase } i \text{ of outbreak in exogenous area} \]  
which is calculated by  
\[ p_i = \text{Beta}(k_i+1, N-k_i+1) \]  
where  
\[ N = \text{total number of animals in the exogenous area} \]  
\[ k_i = \text{average number of infected animals in exogenous area during phase } i \text{ of outbreak} \]

In the next two steps, it is calculated whether the preventive measures in use in the exogenous area and the target DPLA will detect the infected animals in the export batch, if any. Examples of these preventive measures are: clinical inspection of the animals, issue of health certificates, quarantine, blood sampling for serological testing or any combination of these. The Hypergeometric distribution is used to determine the number of infected animals in the test sample. If this is one or more, the Binomial distribution is used to account for the sensitivity of the test used or the quality of the veterinary service performing the clinical inspections. When one or more infected animals are detected, the export batch is returned to the exogenous area.

If the preventive measures fail to detect the infected animals, calculations are performed to determine whether the infected animals come into contact with susceptible animals. This will depend on the type of animals that are imported, their destination in the DPLA and the total number of susceptible animals in the DPLA. For each type of animal a probability on contact with susceptible animals (P_{contact}) is entered into the model. Sampling from a Uniform (0,1) distribution will give a random number between 0 and 1. Only if this random number is smaller then or equal to P_{contact}, contact with susceptible animals will occur.

The last step in determining whether the imported animals will cause an outbreak is to check if the amount of virus excreted by the imported animals is sufficient to infect the susceptible animals with which they come into contact. If so, the model registrates an outbreak and stores its main characteristics: the date, the area of origin of the virus, the causing risk factor and the region in and farm type on which the outbreak occurs. Then the model loops back to perform
similar calculations for the other risk factors. Because the model determines for each risk factor separately whether or not it will cause an outbreak in the target DPLA, it is possible that on one day the virus will be introduced twice or even more times. Most of the probabilities are, however, very small probabilities, which should only lead to few outbreaks over an extended period of time.

DISCUSSION AND CONCLUSION
The simulation model described is under development now. Quantitative risk analysis seems to offer a good opportunity to calculate the likelihood of CSF and FMD virus introduction into DPLAs of the EU. Many exogenous areas and risk factors may contribute to this likelihood of virus introduction. Therefore a lot of quantitative information is needed to perform the calculations in the simulation model. Because not all information is readily available from literature and databases, expert elicitation will be used to obtain lacking information. Sensitivity analysis of the model should indicate which parameters particularly influence the likelihood estimates. Quantitative information on these parameters is especially important in estimating the risk of introduction of CSF and FMD virus into DPLAs of the EU and research should be dedicated to quantifying those parameters more precisely, if possible.

ACKNOWLEDGEMENTS
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REFERENCES
THE SPREADING OF LIVER DISEASES WITH RESPECT TO PATIENT’S LIFE AND LABOUR CONDITIONS: RISK FACTORS

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The paper describes the results obtained by the authors in relation to analysis of risk factors which initiate the spreading of hepatitis A, B, C as well as other hepatitis forms and liver cirrhosis for separate groups of patients in different regions of Bashkortostan Republic (Russia). The specific features of Bashkortostan regions are caused by the significant number of hazardous chemical and petrochemical enterprises.

The main conclusion concerns the fact that the scale of the spreading above mentioned depends essentially on the environmental situation and the labour conditions for population in the regions to be considered.

Among the factors to be investigated the following ones must be underlined:

(i) the type of toxic al agent concerned with patient’s work which influence his initial state,
(ii) the duration of patient’s contact with dangerous substances for the given groups of employers,
(iii) the interaction between the results of liver diseases treatment and the level of wastes and pollutions in the correspondent region.

The authors show the ways for practical estimation of risk degrees for liver diseases appearance and propose the strategy of these diseases treatment which involves the information on the patient’s life and labour conditions. In particular the algorithm for the noted degrees ranking based on prognosis of the liver disease probable decompensation has been proposed. This algorithm is effective mainly for the non-manifested (in clinical sense) issues.

Finally some recommendations regarding the high risk degree prevention are formulated.
HEALTH RISK ASSESSMENT IN DEPEND ON ANTROPOGENIC ENVIRONMENTAL CONTAMINATION UNDER EQUIPMENT OPERATING IN RUSSIA GAS INDUSTRY.

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ABSTRACT
The paper deals with issues of disclosing of benz(a)pyrene (BP) impact on geospheres of human inhabitance - atmosphere, soil, vegetation, open water reservoirs, etc. and health risk assessment in depend on anthropogenic environmental contamination under equipment operating in Russia gas industry.

The integrated analyses and danger generalisation of anthropogenic impact of gas industry's enterprises on environment revealed the sphere of scientific researches of xenobiotics substances, some of which have extremely high toxicity. Among organic compounds PAH and nitro-PAH are quantitatively the most numerous groups out of the chemical compounds list that might be accumulated in living being and produce carcinogenic and genotoxic effects on human.

As a rule, PAH are detected in environment in a small quantities, as a trace level. Therefore, to their determination is applied the most sensitive and selective methods of up-to-date analytical chemistry and so specific methods sampling and samples preparation for analysis.

However scientific aspect is not less important because it makes possible to obtain information on this compounds environmental level, to study their behaviour in gas streams, spreading in industrial and environment. So the investigations are directed to professional and ecological safety in gas industry.

The environmental carcinogenic PAH pollution level is evaluated by BP content - the most strongest ant stable indicator compound. BP has the maximal permissible concentrations (MPC) established by sanitary surveillance bodies in atmosphere of industrial and residential areas, in soil and fresh water reservoirs.

The main sourer of environmental contamination by carcinogenic PAH is hydrocarbon fuel combustion in industrial furnaces, boilers, vehicles engines, heating systems. The fuel combustion in different classes of fuel using equipment (FUE) creates the BP formation conditions in quantitatively depended on fuel type, burning way and regime, etc.

PAH get into the atmosphere, water reservoirs, soil, plants, human and animal food-stuffs out of different sources. However PAH levels in different biosphere parts can be distinguished in several folds. The assessment of danger human contact with these compounds depends on PAH level.

Inspite of available PAH information in all gas industry this field of research didn't involved environmental PAH circulation, quantity of PAH formation and emissions at natural gas burning in FUE combustion chamber.
The main purpose of our study was the integrate investigation BP environmental levels in the gas industry enterprises location to clear out the connection between gas facility’s exhaust and BP content.

Study of environmental pollution by PAH(BP).

The research was carried out at a different branches of gas industry enterprises (gas processing, underground storage, production and transmission) located in various nature-climatic areas.

BP detection was conducted in more than 500 environment samples (atmospheric air, soil, water, plants, snow cover).

The results, presented in the table 1, demonstrate that gas industry brings insignificant contribution in environment pollution by BP, probable at the exception of soil contamination in soot production process.

Table 1.

<table>
<thead>
<tr>
<th>Maximal permissible concentration (MPC) in environment</th>
<th>Gas industry branch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Processing</td>
</tr>
<tr>
<td>Atmosphere, 1 ng/m³</td>
<td>1-3 MPC</td>
</tr>
<tr>
<td>Industrial area</td>
<td>&lt;1-2 MPC</td>
</tr>
<tr>
<td>Residential area</td>
<td>≤1-20 MPC</td>
</tr>
<tr>
<td>Soil, 20 mg/kg</td>
<td>≤10-11,2 mg/kg</td>
</tr>
<tr>
<td>Vegetation, 10 mg/kg</td>
<td>&lt;1-20 MPC</td>
</tr>
<tr>
<td>background level</td>
<td>min-max.</td>
</tr>
<tr>
<td>Water, 5 ng/l</td>
<td>&lt;1-20 MPC</td>
</tr>
<tr>
<td>Snow cover.</td>
<td>27-44,7</td>
</tr>
</tbody>
</table>

Study of BP content in exhaust gases.

Gas pumping units (GPU) operating are the most important source of BP emissions in industry. The results of BP content GPU exhaust gases, using natural gas as fuel, have shown fluctuations in depend of unit’s type. BP concentrations have shown the fluctuations from tens to hundreds ng / m³. But found levels are not high relatively for exhaust gases of gas industry in comparison with other fuel energetic industries.

The calculation of specific indexes of BP emission for a unit of fuel gas has been carried out. Taking account of high consumption of fuel gas from 300 to 600 m³ /h, the specific emissions of BP also amount to significant values reaching 1-15 mg/m³. The problem of the necessity of measures for BP reducing in the emissions composition is being solved.
Investigation on PAH composition and PAH profile in exhaust gases and environment.

Study of the individual PAH content was carried out for some environmental samples (exhaust gases, soil, reservoir water, soot) with the high BP concentrations. Investigated PAH are related to the priority raw taking account their environmental proliferation and carcinogenic and mutagenic extent.

15 - 18 PAH compounds with a number of benzene rings from 4 to 7 were identified both qualitatively and quantitatively. 3 - 4 rings PAH are presented in the most high concentrations in the samples. Together with BP some other strong carcinogens are observed as traces: dibenz(a,h)anthracene, dibenz(a,h)pyrene, dibenz(r,s,t)pyrene. However a light non-carcinogenic compounds predominate in PAH composition.

The exhaust gases and environmental objects quit often have similar PAH profile, demonstrating a specific emission sources (Table 2).

Cancer risk assessment

<table>
<thead>
<tr>
<th>Table 2.</th>
<th>Mean values of concentration ratio of individual polycyclic aromatic hydrocarbons and benzo(a)pyrene in environmental objects.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exhaust gases</td>
</tr>
<tr>
<td>1</td>
<td>Phenanthrene</td>
</tr>
<tr>
<td>2</td>
<td>Pyrene</td>
</tr>
<tr>
<td>3</td>
<td>Chryrsene</td>
</tr>
<tr>
<td>4</td>
<td>Fluoranthen</td>
</tr>
<tr>
<td>5</td>
<td>Benzo(α)anthracene</td>
</tr>
<tr>
<td>6</td>
<td>Benzo(b)fluorantene</td>
</tr>
<tr>
<td>7</td>
<td>Benzo(k) fluoranthene</td>
</tr>
<tr>
<td>8</td>
<td>Perylene</td>
</tr>
<tr>
<td>9</td>
<td>Benzo(α)pyrene</td>
</tr>
<tr>
<td>10</td>
<td>Benzo(α)pyrene</td>
</tr>
<tr>
<td>11</td>
<td>Benzo(g,h,i) perylene</td>
</tr>
<tr>
<td>12</td>
<td>Dibenz (α,β) anthracene</td>
</tr>
<tr>
<td>13</td>
<td>Dibenz(α,β) anthracene</td>
</tr>
<tr>
<td>14</td>
<td>Dibenz(r,s,t) pyrene</td>
</tr>
<tr>
<td>15</td>
<td>1,2,3,4 dibenzpyrene</td>
</tr>
<tr>
<td>16</td>
<td>Dibenz(a,e) pyrene</td>
</tr>
<tr>
<td>17</td>
<td>Dibenz(α,h) pyrene</td>
</tr>
<tr>
<td>18</td>
<td>Coronene</td>
</tr>
</tbody>
</table>

The advance in risk assessment account mechanisms is achieved in oncological disease area. Our intentions on risk assessment are based on this fact. At the first stage the most reliable risk assessment procedures on environment protection adopted to carcinogenesis only were
fulfilled by EPA. One of the most important problems the health population in Russian morbidity structure is oncological morbidity.

The base to reveal correlation between BP concentrations and probable negative effect on human health is being prepared at the present stage of obtained information. For this purpose the oncological morbidity and total discharge indexes of gas industry facilities are connected.

Health risk assessment executed by Carnot Technical services according to Gas Research Institute order, taking into consideration the boiler discharge speed and total PAH emission at using gas transmission equipment (turbines) has shown, the cancer disease risk is less 1 per mln. for energosystem pollution sources.

Because of complexity gathering and processing data for risk assessment and lack of time it wasn't carried out finally to the paper publication. Straight extrapolation the world's methods couldn't allow to evaluate them properly. It should be have hygienic and epidemiological reasons to possible apply the risk assessment methods in the concrete region conditions. The study in this trend is in a progress.
A RAT MODEL FOR DOSE-RESPONSE RELATIONS OF ENTERIC PATHOGENS

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Quantitative microbiological risk assessment is an increasingly important tool for the evaluation of the safety of water and food, and for regulating international trade. In this framework, dose-response assessment is the evaluation of the probability of adverse health effects in relation to the ingested number of micro-organisms. Current models are based on limited information from volunteer studies and outbreak reports. We aim to develop a dynamical mathematical model of intestinal infection and disease, and to support model development by experiments with laboratory animals.

Adult, male Wistar rats were fasted overnight and exposed by gavage to different doses of three enteropathogenic bacteria. Challenge with $2.0 \times 10^{10}$ *Salmonella enterica* serovar Enteritidis induced serious systemic illness in all animals, and was associated with a significant loss in body-weight. Challenge with $3.5 \times 10^9$ *Campylobacter jejuni* or $7.5 \times 10^9$ *Escherichia coli* O157 did not induce clinical illness but decreased weight gain in the *C. jejuni* group compared to that of controls. Diarrhoeal symptoms were not seen in any of the animals, but in the *C. jejuni* group an increase in faecal moisture content was noted. Also, infection with *C. jejuni* resulted enteritis-related symptoms. In contrast to the negative control strain *E. coli* WG5, all pathogens could be isolated from faeces up to day 6 after inoculation (end of experiment). *S. Enteritidis* was invasive, in contrast to *C. jejuni* and *E. coli* O157.

*S. Enteritidis* and *C. jejuni* infected animals did show alteration of some haematological parameters. In the *S. enteritidis* inoculated animals blood thickening and neutrophily indicated severe infection.

Infection, defined as faecal shedding was dose-related, *C. jejuni* being more infectious than *E. coli* O157, which was more infectious than *S. Enteritidis*. For the latter organism, a dose-response relationship was also found for some haematological parameters: (notably neutrophils) and histopathological effects in the intestine.
CONTROL OF IRRIGATION CONDITIONS TO MINIMIZE THE RISK OF CROP YIELD LOSSES

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Methods of completing season irrigation schedules for crop rotation fields are proposed for the cases when there is an irrigation water shortage. Crop species cultivated and climatic zones are taken into account. As a result of the application of methods developed to solve the problem of water resource allocation, during all the irrigation period the humidity of the active soil layer is supported between critical point and humidity with the least moisture-holding capacity. Due to it the risk of crop yield losses because of moisture shortage in the root layer of soil is reduced. The second problem of completing season irrigation schedules lies in the determination of the most rational value of hydromodulus of systems when the level of water supply is given. For this purpose the dynamics of soil humidity change is modeled on the basis of balance equations with regard to meteoparameter series for many years. The problem of mathematical programming is solved and the number of fields irrigated simultaneously is determined when the crop rotation and type of irrigation facilities are given. Using this number one calculates the value of hydromodulus of the irrigation system designed. The methods developed have been formalized in the form of computational algorithms and realized as programs for personal computers. They have been introduced to the industry as an integral part of the computer-aided effective irrigation control system.
FORECASTING AND COMPENSATION OF DAMAGE CAUSED BY FOREST FIRES IN SIBERIA

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The article is connected with the problem of forest fires in Irkutsk region (Siberia). Forest resources and fires statistics have been analysed. Approach and model for natural disasters, including fires forecasting were described. By the model a range of forest fires in 1999 has been assessed. Some variants of compensation mechanism of damage caused by the fires are discussed.

Irkutsk region is very rich in forest resources - about 12% of mature forest reserves and 13.6% of coniferous species of Russia. Main characteristics of forest resources are presented in paper [1]. The total area of forest resources of the region is 71445 thousand ha or 92.2% of the regional territory. Forest lands (the lands covered and non-covered with forest but intended for forest raising ) occupy 84.7% of the regional territory whereas for Russia this index is equal to 75.1%.

Regional reserve of mature forests is estimated at 5.32 billion cub.m, of them 4.73 billion cub.m fall on the fraction of precious coniferous species. Provision of population with mature forests changes in the range from 3 m$^3$ per capita to 94876 m$^3$.

The forests of Irkutsk regions are characterised by a high burning rate. Their fire resistance, being the characteristics reflecting degree of resistance of different forests and forest areas to fire, is a fire risk class. As of January 1, 1993 12% of the territory of the forest resources belongs to the first class, 21% - to the second, 39% to the third, 17% to the forth and 11% to the fifth class [1]. Average fire risk class in the region is 2.95 [2]. Duration of fire risk period in the region according to the data for the years 1959-1990 has reached 170 days [1].

Territorial and chronological dynamics of forest fires reflects climatic conditions. The first fires are as a rule observed in the second half of April and the last ones in the first decade of October. The peak number of fires falls on May when soil is intensively dried up due to minimum air moisture of 18-20% and lack or insignificant number of rainfalls. Originating first in the southern part of the region the fires, due to increase of average daily temperatures, cover middle and northern areas of the region. The burnt out areas are the largest in summer months. Due to low population density the fires in the northern districts which are hard to reach, often cover large territories.

Analysis of statistical data on forest fires recorded in Irkutsk region for the period from 1947 to 1996 testifies to their frequency particularly in the dry periods. Thus liquidation area of forest fires has of peak character (Figs. 1).

On the average for the multiyear period the number of forest fires is equal to 1330 and average area of their liquidation is 104 thousand ha, thus, the average area of one fire is 78
ha. In Irkutsk region particularly severe consequences in the recent years were caused by the fires of the years 1993 and 1996. In 1993, compared to the year 1992, the number of forest fires increased from 919 to 2721 and area of their liquidation increased almost by an order from 31.1 thousand ha to 307 thousand ha, average area of one fire is 113 ha.

Fig. 1. Dynamics of specific area of forest fires on the territory of Irkutsk region for the years 1947-1996.

About 2800 fire locations, which is the highest number for the whole period, were recorded in 1996 that made up 12% of all the recorded forest fires on the territory of Russia [3]. In so doing the forest fire liquidation area was estimated at 365.3 thousand ha that made up 62% of the forest fire liquidation area of the territory of the whole country. Average magnitude of one fire at this year, as in the fire risk season of 1993, exceeded the magnitude of 100 ha which serves as criterion for estimation of the extraordinary situation at fire.

According to the data of the Ministry of Emergency of Russia [3] the anthropogenic factor (90%) and thunderstorms with lightning (10%) are considered the main reasons of ignition. In addition to natural and climatic conditions and repeating long-term dry periods, the main reasons of forest fire spreading for large areas, are lack of facilities and equipment for timely detection and elimination of forest fires particularly in remote northern territories.

The scales of the fire risk season for the specific year for a definite territory can be estimated only after collection of the data on: the formed snow reserves, forecast for spring snow melting and long-term forecast of precipitations and air temperatures for a spring-summer period of the expected season and forecast of the runoff water content of rivers.

Rather reliable forecasts with the lead time from 1 to 5-10 years of average monthly, average season and average yearly air temperatures, number of tributaries of water reservoirs, river runoffs, precipitations, including those with stable and nonrandom connections with characteristics of forest fires can be obtained on the basis of the methods for long-term forecasting of natural and climatic processes (analogue-coincident relationships, discrete-continuous, self-learning, probability methods) developed in Energy Systems Institute of Russian Academy of Sciences in the 80-90s years [4].
The indicated methods and algorithms are realized as a hybrid information-prognostic system GIPSAR for long-term forecasting which includes the above forecasting methods. The system also allows the analysis of statistical information to select influencing factors. The estimates of efficiency of water inflow forecasts which were made in 1997-1998 by using this system showed that on the average the errors in forecasts of the side inflow to the Bratsk reservoir with a year in advance amounted to 19% of the value of dispersion range for points of the series and the errors in forecasts of available inflow to Lake Baikal were equal to 10%. Errors in the forecasts of mean annual temperatures in Irkutsk for the last winter 1997-1998 made up 15-22% and those of mean winter temperatures were only 9%.

The described system was also applied to forecast a fire risk on the territory of Irkutsk region. The area subjected to fire is expected to increase in comparison to the year 1998 with a probability of 85% that is determined by the tendency of moistening, temperature trends and forecasts of precipitation. The forecast range of the total area of fires can reach 130-210 thousand hectares in 1999.

Forest fires cause huge damage to the regional economy, and precise assessment of its volume is an extremely difficult task. This is explained by numerous forms of fire impacts, some of them being of lasting or remote character. Use of different technical and organizational measures leads in principle to reduction in fire scales. However, they can not exclude completely or to a considerable extent reasons for fires, and therefore, in parallel with forecasting of frequency and scales of forest fires, it is important to develop different ways of economic damage compensation. The current status of economic development of Russia and its regions substantially limits application of potential mechanisms of the damage compensation. Nowadays the damage caused by forest fires is really covered only from the regional budget. Unfortunately, the amount of money allotted is extremely small by virtue of objective reasons and it covers only several percent of the damage estimated. This situation makes one search for additional compensation sources.

The most rational approach to this problem could be creation of a regional system of damage compensation, which would include different compensation mechanisms [5]. In reality the list of such mechanisms is very limited. Ecological nonbudgetary funds could potentially be referred to such mechanisms. However, a low level of solvency of industrial enterprises, i.e. sources of harmful emissions into the atmosphere, does not allow accumulation of sufficient means to compensate damage caused by fires.

Nowadays it is most real to discuss different variants of insurance usage. A catastrophic character of forest fire impacts calls for a thorough analysis of the ways and scales of insurance introduction. First of all, it should be underlined that due to the relatively low capacity of insurance market in the region and Russia as a whole it is senseless to speak about full damage compensation at the expense of insurance. In any variant consideration should be given to an individual share of the budget means and the means of insurance organizations in fire damage compensation.

Then it is necessary to separate a random component in damage manifestation, otherwise attraction of insurance becomes inexpedient. Analysis of the statistical data shows that the forest fires themselves are not random events, i.e. their probability in the region for a year is equal to unity. Random are the number of fires, their locations, the area burnt out, the economic damage. Two variants of insurance protection are possible here. Each is based on
the principle of the excess (exceedent) of some value, e.g. the mathematical expectation of the total area of fires. A long-term mean value of the total area, for which some money from the regional budget is planned for damage compensation, can be obtained from the statistical data. Excess of the real area over the mean one will cause attraction of the insurance reserves to cover additional damage (the pattern of loss limit). At the current stage of development of regional insurance markets, if complexity in spread of such risks at the Russian and international reinsurance markets is taken into account, a pattern of quota-loss limit structure of the insurance coverage seems most probable. In this case participation of the insurance companies is limited by both the total area of fires and the fraction (quota) in damage compensation which exceeds the set value (loss limit).

Possibility and effectiveness to apply insurance for compensation of damage caused by forest fires were estimated on the simulation model of the financial state dynamics for the insurance company which is based on the Monte-Carlo technique. The model is described in detail in [6]. The calculations were made for the damage probability distribution function that was constructed from statistical data on the total yearly area of fires and the estimation of specific damage amount. Fig. 2 presents a histogram of the total damage distribution.

![Fig. 2. Histogram of distribution of the total damage of forest fires](image-url)

The histogram was built on the base of the following damage ranges (in million rubles): 1 - to 20, 2 - from 20 to 40, 3 - from 40 to 80, 4 - from 80 to 160, 5 - from 160 to 320, 6 - above 320. The damage distribution function is characterized by sufficiently high frequency of heavy damages due to vast areas of the burnt-out forest. Such form of the distribution function proves complexity of insurance introduction.

The calculations were done for two compensation variants. The first variant considers the loss limit pattern, in which the total area of fires or what is the same, the total damage was used as the limiting value. The calculations show that this pattern is applicable only, when the loss limit is no less than 320 million rubles. In this case insurance fully covers losses above the limit. The calculations reveal that for the relatively low rate (about 5%) the probability of insurance company ruin is no higher than 10%. By using statistics of the long-term observations reduction of the loss limit size essentially increases the ruin probability, and its decrease is possible only by the significant increase of the initial insurance reserve. In the nearest future this approach seems hardly probable.
The loss limit can be decreased by using the results of forecast on the total area of fires in the calculations. In this case the limit can be decreased to 170 million rubles without rise of the ruin probability.

Similar calculations on the quota-loss limit pattern show that the share of budget and insurance compensations is the most acceptable form for fire damage compensation in terms of possibility to decrease the loss limit (even with application of the long-term statistics) and the insurance rate.

REFERENCES


THE DANGER OF THE CHEMICAL WEAPON BURIAL PLACE IN THE BALTIC SEA

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The purpose of this work - the analysis of ecological and sanitary - microbiological researches of the chemical weapon burial place in the Baltic Sea.

Within the framework of Sea ecological patrol executed in 1995 the complex ecological researches in places of flooding after the Second World War of the German chemical weapon in Bornholm and Gotland hollows were carried out.

The results of study of the contents of heavy metals in waters Bornholm and Gotland hollows given in 1994 (results of 1995 are still processed), have shown is abnormal high quantities of heavy metals: lead, manganese, molybdenum etc. what also to be caused by the technical reasons, switching and flooded chemical weapon.

Sanitary - microbiological researches of water and ground have shown, that all tests taken in Bornholm and Gotland hollows, contain the lowest quantity of bacteria, that testifies to presence of toxic substances interfering development of bacteria.

The results of the analysis of tests have not given positive results and testify to absence in tests of poisoning substances in concentration 0,01 mg/litre.

Carried out of research have not allowed to reveal essential changes of an environments representing real danger to ecology of the Baltic Sea.

At the same time some anomalies in Bornholm and Gotland hollows (increased contents microelements and heavy metals, high integrated transparency of water, significant quantity of mollusk remains) are found out, that testifies to possible local influence of technical objects, including possible influence of the flooded chemical weapon, including possible influence of the flooded chemical weapon.

As a whole, the ecological situation in the Baltic Sea is characterized by high tension over technical influence of all countries of the region, in which lives more than 80 millions people.

In this connection the systematic tracking, control and forecast of development of ecological environment on key sites of Baltic is necessary, including places of flooding of the chemical weapon.
REFERENCES


TRACK 5
SESSION 5

CHERNOBYL – RADIATION – SOMATIC CONSEQUENCES
LONG-TERM CONSEQUENCES OF THE CHERNOBYL DISASTER AMONG CHILDREN OF 0-14 YEARS OLD AT THE TIME OF THE ACCIDENT RESIDING NOW ON RADIO-ACTIVELY CONTAMINATED TERRITORIES OF UKRAINE

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The population of persons who were children of 0-14 years old at the time of the accident and were residing in the contaminated territories was formed after the Chernobyl disaster in Ukraine. The joint and combined exposition of iodine, cesium, strontium, plutonium and other radioisotopes was the most biologically dangerous for that population. The character of exposition to $^{131}$I is acute (thyroid doses were 0.3-200 cGy) and to other radioisotopes is prolonged chronic (10-12 years). The total accumulated dose of radiation is related to category of "low and very low doses of radiation" — 2-120 mSv. The factors with well-known morbidity effects and which was present before the accident were not involved in the study.

To reveal effects of long-term chronic exposure to radiation the first time registered cases of chronic diseases were estimated. In comparison with indices calculated before the accident increasing of the morbidity indices was revealed for the blood system and hemopoietic organs diseases, including iron-deficient anemia; endocrine system pathology, including that of thyroid gland; digestive system diseases, including gastritis and gall-bladder diseases; mental disorders, including behavior ones; among cardiovascular system — myocardium metabolic disorders.

The $^{131}$I radioisotopes' effect manifested itself in thyroid cancer cases with exposure doses range 14.5-270 cGy. No thyroid cancer cases were registered among children residing within studied territory before the accident. The correlation was revealed between diseases of skin and subcutaneous tissue, genitourinary system, mental disorders and dose value.

Keywords: children, ChNPP, chronic irradiation, thyroid gland, correlation-regression analysis.

Child population of Northern Ukraine was exposed to combined exposure of radioisotopes of $^{137}$Cs, $^{90}$Sr, $^{239}$Pu, $^{131}$I and other. Exposition to $^{131}$I was acute (for 10 days); other isotopes' exposition was chronic and was a consequence of residing on the contaminated territories. The soil contamination density was from 37 to 1480 kBq/m$^2$ and the effective equivalent dose of total exposure came to 2-120 mSv accumulated for 10-12 years [1, 8]. There is a considerable number of scientific works on health condition of children affected in a consequence of the Chernobyl accident [2, 3, 4, 5, 6, and 7]. In presented work we are submitting some results of a large-scale epidemiological prospective cohort study. Clinical, epidemiological, statistic methods were used.

After thought sampling persons born in 1972-1986 and residing in the countryside of Ukrainian Polissya were included into the studied cohort. Total amount was 34000 in 1986. Of them — boys 51-52%, girls 48-49%. Number of person-years being in the risk came to 215000.
Dose distribution for the cohort is shown on figure 1.

![Graph showing dose distribution](image)

**Figure 1.** Distribution of the effective equivalent total doses accumulated for 10–12 years in child population of the Chernobyl disaster victims.

Comparative morbidity analysis for groups with maximal values of a dose difference ("less 10 mSv" and "50 mSv and more") was conducted. A group with dose less 10 mSv was taken as a group of the internal control. The morbidity indices were grouped by disease classes accordingly ICD-9.

| Table 1. Distribution of diseases by classes accordingly ICD-9. |
|---|---|
| **Disease class name** | **Code by ICD-9** |
| 1 Infection and parasitic diseases | 001–139.8 |
| 2 Neoplasmas | 140–239 |
| 3 Endocrine system diseases | 240–279.9 |
| 4 Blood system and hemopoietic organs diseases | 280–289.9 |
| 5 Mental disorders | 290–319 |
| 6 Nervous system and sensoric organs diseases | 320–389.9 |
| 7 Blood circulation system diseases | 390–459.9 |
| 8 Respiratory organs diseases | 460–519.9 |
| 9 Digestive system disorders | 520–579.9 |
| 10 Genito-urinary system diseases | 580–629.9 |
| 11 Skin and hypodermic tissue diseases | 680–709.9 |
| 12 Bone-muscular system diseases | 710–739 |

Only first revealed cases of chronic diseases were taken into consideration. 1988 was appointed as start because the territories and the contingents of observation were finally defined by that moment. Time of exposition was 2 years then. A coefficient of an effect of screening was from 1.2 to 2.8 and it was the highest for "Endocrine system diseases". Computing of an absolute risk and standardized coefficients revealed growth of the morbidity indices in 1996 in comparison with 1988 as in the main group so in the internal control group. Relative risk of beginning of disease in the internal control group is shown on figure 2. An index of accumulated morbidity was used.
Figure 2. Relative risk of beginning of a disease for persons having dose 50 mSv and more in comparison with persons having dose less 10 mSv, for 95% and 99% confidence. A correspondence between X-axis' marks and real diseases' names can be seen above in Table 1.

It can be seen that relative risk is most significant for "Endocrine system diseases", "Blood system and hemopoietic organs diseases", "Digestive system disorders", "Mental disorders", "Skin and hypodermic tissue diseases", "Genito-urinary system diseases". Assuming linear dependence a Pearson's coefficients of pair correlation were calculated. The coefficients shown that there is an association between morbidity indices of described above classes of diseases and doses with significance level .01 and .05.

Two-factorial analysis of dependence the morbidity indices on doses and time of residing on the contaminated areas was conducted. See figure 3.

Figure 3. Result of analysis of dependence the morbidity indices on doses and time of residing on the contaminated territories. Confidence is 95%. A correspondence between X-axis' marks and real diseases' names can be seen above in Table 1.
Both ionizing irradiation and residing in the contaminated areas are making their contribution to a morbidity forming and moreover a fact of the residing is prevailing. Statistical estimation for the thyroid cancer cases was conducted. The peak was in 1991 year. The index' value came to 0.42 per 1000; standardized by the world standard population index was 0.9 per 1000. A range of thyroid dose values among children affected by thyroid cancer was from 14.5 to 270 cGy. There were no registered cases of thyroid cancer among children residing in those areas before the accident.

On conducting of large-scale prospective study we established that a population of children exposed to the acute dose of radiation and being exposed to low level doses of the chronic exposure of ionizing irradiation was formed. People residing on the polluted territories and having total dose 50 mSv and more are under higher risk for "Endocrine system diseases", "Blood system and hemopoietic organs diseases", "Digestive system disorders", "Mental disorders", "Skin and hypodermic tissue diseases", "Genito-urinary system diseases". Contributions into morbidity forming of the ionizing irradiation and the residing in the contaminated areas is statistical confident. Influence of dose level on forming of non-tumour pathologies was not established.

This study is preliminary. Further collecting of data on health condition of persons exposed in child age and their descendants is necessary.

REFERENCES
CO-LABORATORY RESEARCH ON DEFINITION OF DOSES OF RADIATION, RECEIVED BY THE LOCAL POPULATION IN RESULT OF FAILURE ON SIBERIAN CHEMICAL COMBINE ON APRIL 6, 1993


Siberian Med. Univ. (Tomsk, Russia)1
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Institute toxicologic (Moscow, Russia)4
Institute radiologic (St.Petersburg, Russia)5
Inst. Epidemiologic (Kiev, Ukraina)6
Cntr. on Radiol. Of Safety of Space Flights (Moscow, Russia)7.

The scientists from Russia, Ukraine and Netherlands have participated in the investigations of radiative doses. A cytogenetic method and investigation of tooth enamel by a method of an electronic spin resonance (ESR), as well as micronuclei test were applied for definition of radioactive doses received by the population. Four settlements located between 12-30 kms away from the failure sight, were investigated. At the Samus settlement, the blood of 250 schoolchildren and teachers was taken four times for the analysis at, 3-5 days, 6 months and at 1 and half years, following the failure. Moreover cytogenetic investigations of blood cells in workers of factory and on river ships were carried out. The data obtained testify that in 5 % of cases of the inhabitants of the Samus settlement, a dose of radiation effect exceeding 1000 mSv, in 36 % from 500 up to 1000 mSv, in 27 % from 250 up to 500 mSv, and in 22 % less than 250 mSv is registered. The concurrence of results of interlaboratory research has established 87 % of the cases. The distinctions concerned the results of the examinations of the fishermen where the method ESR gave high results (more than 1 Gy) and chromosomic method and micronuclei gave low ones (less than 0.5 Gy). The school children of junior classes had less changes in cytogenetic apparatus than school children of the senior classes. A large number of cytogenetically aberrated cells were especially observed in the people born between 1964 and 1968. It was found that during these years, serious failures at the Siberian chemical combine occurred causing radiation pollution of the district. The number of cells with cytogenetic aberrations was considerably less in the people arriving in Samus after 1980. However, the radiation effects on blood cells (in vitro conditions) in a dose of 0.5 Gy causes extensive changes in the cells of migrants than in the natives. The medicinal preparations pentoxylum and leukogenum can effectively reduce the level of cytogenetically aberrated cells in 2-3 fold. It was noted simultaneously that these preparations sharply improve immunologic and haematologic parameters in the local inhabitants of the Samus settlement.
ASSESSMENT OF HEALTH RISK AND EFFICACY OF THERAPY OF LIQUIDATORS OF CHERNOBYL ACCIDENT

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ABSTRACT
The computer method of risk assessment of occurrence of pathologies in organism is developed on the basis of theory of catastrophes and optimum control. Created computer technology allows on the isolated data of clinical inspections, to receive quantitative accounts of ranging risks of development of pathology in separate vital-important systems of organism (VISO). The critical values of integrated parameters describing immune, endocrine, energetic and other VISO are calculated, at approximation to which risk of occurrence of pathology sharply grows. The offered method allows: 1) to estimate efficiency of carried out therapy; 2) to carry out the comparative analysis to reveal most of "weak" link in reserve opportunities of organism; 3) to develop individualized complex therapy, which minimizes effect of preparations having different-directed vector of actions on different systems of organism; 4) to predict consequences of various therapeutical schemes of patient’s treatment.

With the help of created software the organism functional state (OFS) of liquidators of Chernobyl accident was estimated. For it the parameters used which characterize a general state of organism and also states of energetic, immune, endocrine and other systems. Results allow to look after dynamics of change of OFS during therapy and to define, as far as the treatment was effectively carried out. Account of individualized dose thresholds of the adverse factors of environment, since which probability of irreversible changes in organism sharply grows, allows to receive an individualized complex estimation of FSO and to determine size of reserve opportunities of patient. It has large importance for realization of selection of persons participating in performance of various tasks, requiring significant physical loads, connected with influence of adverse factors of environment.

THE MATHEMATICAL METHOD FOR CALCULATION OF HEALTH RISK AND EFFICACY OF THERAPY
Efficiency of VISO in overcoming or reducing negative consequences of effects of low radiation doses to a considerable extent depends on organism reserve abilities, balanced various regulation mechanism functioning. The functional state’s integrated valuation obtaining problem still remain one of the most actual tasks of modern medicine on solving of which depends further radiation medicine. Let us introduce integrated indices Ωi characterizing the degree of misbalance of different links of immune (i=1), thyroid (i=2), hemopoiesis (i=3), energetic (i=4) and antioxidant (i=5) systems. Using these indices which characterize degree of the systems’ functioning violation and their reserves, we shall develop a mathematical method of risk assessment of pathological and prepathological state emergence. Using presentation about organizational security of biological system it is possible to put forward a supposition that norm position is characterized by balance both with external and internal effects. Prepathology position is determined by internal balance violation. The violation both internal, and external balance corresponds to illness.

On the base of works dealing with methods of theory of catastrophes [2] a following algorithm of health risk assessment can be suggested: 1) information, characterizing parameters of immune, endocrine, energetic, and antioxidant organism systems, is inputted
from data bases; 2) by means of developed mathematical models with the help of inputted data the indices characterizing appropriate functional systems are estimated; 3) the polynomial coefficients of butterfly catastrophe are calculated on the base of these indices; 4) the bifurcation values of the parameters at which system states’ number is changing are calculated; 5) reserve possibilities and risk of negative changes of each of above systems are estimated by remoteness of parameters characterizing appropriate index from its bifurcation value.

Risks of transfer from one functional state into another for above systems (R_i) are determined as follows: R_i = \Delta_1 / \Delta_{ip}, where \Delta_{ip} - index of i-th VISO state in pathology; \Delta_1 - current VISO index. If \Delta_{ip} = 0, than a transfer from one state into another is considered to be impossible. Total risks of transfer into prepathological and pathological states are determined as follows: R_{ij} = (\Sigma R_{ij}^2)^{1/2}, (i=1,4), where j=1 corresponds to prepathology, j=2 – to pathology; if R_{ij} > 1 it is considered that R_{ij} = 1.

Calculation of optimum ways of therapy correction is also based on the above method. Let us consider the case when pathology corresponds to OFS which is determined by a set of indices \Delta_i. In this connection a task of finding out such parameters changes describing above regulation systems which would transfer the system in a state corresponding to norm emerges. The most effective is optimum way of finding out the minimal path D_{opt} with simultaneous change of parameters of each of systems transferring functional state from pathology to norm. Optimization task statement is following: functional D_N = (D_{Ni}^2)^{1/2}, (i=1,4) must be mini-mized, where D_{Ni} = |\Delta_i - \Delta_{Ni}|, \Delta_{Ni} - bifurcation value of i-th integrated index corresponding to norm. Changes of parameters of each system, bringing OFS to norm, are used as control ef-fects. To solve optimization problem a modified random search method (statistical gradient method) was used. The choice of the method was caused by lack of analytical expression for objective function and by derivatives’ calculation complexity.

Development of method to determinate distance from current OFS index value corresponding to pathology to values which correspond to norm is a base for solution of task of optimum control. An appropriate dynamic model at the output of which a system state index is formed corresponds to each of the considered system. At that control effects are model’s parameters, which determine the status index. Optimum control task solution consists of finding out parameters’ dynamic, which causes transfer from pathology state to norm. Measure of therapy efficacy is the relation between values of risk before and after the application of therapy.

COMPUTER TECHNOLOGY FOR INTEGRATED ESTIMATION OF ORGANISM FUNCTIONAL STATE
By means of developed software numerical study of integrated OFS valuation and risk of prepathologic and pathologic changes in organism were carried out. The personnel data of patients, who have been treated in adult hematological department of Institute of Clinical Radio-logy were utilized. As usual the indices for risk assessment calculated with the help of developed mathematical models. These models allow to determine the dynamics of parameters above VISO, to investigate the radiation influence on control mechanisms, to solve the optimization tasks, connected with account of effective therapy. In this case, as the information in data bases concerning endocrine and antioxidant parameters was incomplete, for OFS estimation instead of these two systems a blood system and parameters characterizing common organism state are used. The data for one of patients and results of computer analysis presented in table.

The results of calculation of immune system indices are illustrated in fig. 1. At left \Delta_i are shown under various shares (z) of T-helper precursors, which are differentiated into normal
mature cells. Column 1 corresponds to $z=1$, column 2 - $z=0.5$, column 3 - $z=0.1$. The middle part shows the optimization task solution, connected with normalization of cellular immune response. The dynamic of control parameters IL1, IL2, IL3, minimizing $\Delta_t$ are shown at right.

Fig. 2 presents the individual relationships between risk and exposure’s dose (D), calculated by model for 3 patients with D=10sGy (curve 1), D=20sGy (curve 2), D=50sGy (curve 3).

### Table.

<table>
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<th>Parameters</th>
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<td></td>
</tr>
<tr>
<td>- reserve possibilities</td>
<td>0.1</td>
<td>max</td>
<td>max</td>
<td>max</td>
</tr>
<tr>
<td><strong>Common symptoms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- weakness</td>
<td>0</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>- sweating</td>
<td>0</td>
<td>++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>- pulse frequency</td>
<td>60-80</td>
<td>77</td>
<td>74</td>
<td>68</td>
</tr>
<tr>
<td>- respiration frequency</td>
<td>16-22</td>
<td>18</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>- temperature</td>
<td>36.0-36.9</td>
<td>36.4</td>
<td>37.2</td>
<td>36.0</td>
</tr>
<tr>
<td>- OFS Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Risk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- reserve possibilities</td>
<td>0.1</td>
<td>max</td>
<td>max</td>
<td>max</td>
</tr>
<tr>
<td><strong>Energetic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- glucose, mmol/l</td>
<td>3.3-6.6</td>
<td>5.3</td>
<td>5.7</td>
<td>4.9</td>
</tr>
<tr>
<td>- glycogen</td>
<td>0.72-0.9</td>
<td>0.82</td>
<td>0.79</td>
<td>0.88</td>
</tr>
<tr>
<td>- LDG</td>
<td>57.4-58.8</td>
<td>58.1</td>
<td>57.8</td>
<td>59.1</td>
</tr>
<tr>
<td>- SDG</td>
<td>0.30-0.40</td>
<td>0.38</td>
<td>0.34</td>
<td>0.39</td>
</tr>
<tr>
<td>- OFS Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Risk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- reserve possibilities</td>
<td>0.1</td>
<td>max</td>
<td>max</td>
<td>max</td>
</tr>
<tr>
<td><strong>Total risk</strong></td>
<td>0.93</td>
<td>1.0</td>
<td>0.94</td>
<td>0.77</td>
</tr>
</tbody>
</table>
The results have importance for realization of selection of persons participating in performance of various tasks, connected with influence of exposure on health.

Fig. 3 illustrates results of endocrine model investigation: 1) the model calculated dependence between thyroid-stimulating hormone (TSH) and D (at left); 2) the dynamics of TSH for norm (curve 1), hypothyroidism (curve 2), optimization task solution (curve 3), connected with TSN normalization (at right). The index of optimization quality $\Delta_2$, that characterize the efficiency of control process, is equal 0.506.

The results of model calculation of hemopoiesis system indices are presented in fig.4. The dynamics of granulocytes (left) and monocytes (middle) for norm (curve 1), periodic neutropenia (curve 2) and optimization task solution (curve 3) and $\Delta_3$ values that characterize the efficiency therapy for chronic myeloleucose (1) and periodic neutropenia (2) (right) are shown. These results indicate, that therapy for periodic neutropenia was more effective.
Thus the elaborated software creates essentially new possibilities for realization of individualized complex therapy, as allows in more details to study effect of various therapeutical preparations on separate links of the VISO, and also to estimate efficiency of carried out therapy. Besides it can be used for: 1) an account of individualized dose thresholds from which the probability of irreversible changes in human health sharply increases, 2) finding out ways to increase efficacy of therapy due to control of separate control mechanisms balance. Its application makes possible essential increase of efficiency of usage of funds spend on patients' treatment, continuation of their long-standing professional activity due to minimization of negative consequences of environment factors having effect on human health.

REFERENCES

ASSessment of spontaneous thyroid cancer risk in Ukraine

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Abstract
Since back in the 80s Ukraine did not keep register of thyroid cancer cases, the reliable evaluations of spontaneous risk are not available. The main purpose of the present research is the quantitative evaluation of age and gender specific background risk for children's population of Ukraine in the period of 1986-1997 and estimate of screening effect since establishment of the Ukrainian Thyroid Cancer Register in 1992. According to the results, screening effect is estimated as insignificant (screening coefficient accounts for 1.27 with 90% CI [0.63; 2.56]). In 1986-1991 in Ukraine, background rate for both genders in 0-14 year-old population is estimated as 0.71 cases per 10⁶ PY with incidence sex ratio of 1.8. Among 1017 thyroid cancer cases, occurred in 0-18 year-olds at the accident in the period of 1990-1997 from the entire Ukraine, 558 cases are estimated as spontaneous and 459 as excess cases.

Introduction and objectives
The universally acknowledged outcome of the Chernobyl accident is a substantial growth in children incidence all over the Ukrainian, Belorussian and Russian areas neighboring the Chernobyl NPP [1]. Numerous researches have been dedicated to analysis of correlation between the observed incidence and exposure after the Chernobyl accident, to calculation of risk coefficients and of minimum latent period [1,2]. Spontaneous thyroid cancer risk, specified for particular sexes and ages, is the essential element of the aforementioned researches.

In this paper, background risk (spontaneous incidence) is taken as incidence caused by the whole range of factors (including screening) save for exposure due to the Chernobyl accident. Unlike many European countries (including Belarus), Ukraine did not compile a register of thyroid cancer cases during the whole pre-accident period. According to generalizing publications [3,4], levels of background incidence vary considerably in different European states. Therefore, the levels of spontaneous thyroid incidence assessed for other countries can hardly be applied to the Ukrainian population.

The main objective of this paper is to obtain estimates for background thyroid cancer risk in Ukraine, specified for ages and sexes, including their uncertainties, as well as to use these estimations in assessing excess incidence.

Materials and methods
The bases for analysis of spontaneous thyroid cancer risk:
1) Ukrainian Register for thyroid cancer cases among individuals, born since 1968 (up to 18-year olds at the time of the accident) [5]. The Register was set up in compliance with the Order of the Ukraine's Ministry for Health care dated January 20, 1992. The Order stipulated for measures on "improvement of endocrinological aid to children and adults in order to reveal diseases on the early development stages". The register accumulates information on thyroid cancer cases registered from entire Ukraine since 1986.
2) Demography database. This database integrates information on the dynamics of age-sex distribution of the population in various Ukrainian regions (oblasts) from 1986 till 1997, published by the Ukraine’s Ministry for Statistics.

Analysis of spontaneous incidence is based on the following assumptions:

1) Minimum latent period for development of radiation-induced thyroid cancer is equal to 4 years, which corresponds to the period of 1986-1989;
2) In 1992, Ukraine altered the methods of detecting thyroid cancer incidence, i.e. since 1992 the screening effect has been taking place;
3) Screening effect is the same for both sexes and all the birth cohorts;
4) All the Ukrainian regions have a common function of age dependence of the background risk.

In compliance with the assumptions taken, all the data under analysis are divided into the following four subsets (Table 1):

(a) Cohort, exposed as result of the Chernobyl accident during the latent period (birth cohorts 1968-1986, thyroid cancer occurrence in 1986-1989);
(b) Cohort of unexposed children until introduction of screening (birth cohorts from 1997, thyroid cancer occurrence in 1987-1991);
(c) Cohort of unexposed children after introduction of screening (birth cohorts from 1997, thyroid cancer occurrence in 1992-1997);

Table 1. Characteristics of subsets analyzed

<table>
<thead>
<tr>
<th>Features</th>
<th>Gender</th>
<th>Subsets under study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(a)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(d)</td>
</tr>
<tr>
<td>Cases</td>
<td>Male</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>92</td>
</tr>
<tr>
<td>Person-Years</td>
<td>Male</td>
<td>28.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>27.1</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>55.2</td>
</tr>
<tr>
<td>(×10^6)</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.0</td>
</tr>
</tbody>
</table>

The first two data subsets are used to calculate age-dependent spontaneous risk not modified by the screening procedure. Subsets (a), (b) and (c) are used to evaluate the screening effect. Subset (d) is applied to analyze spatial pattern of excess incidence.

Age-sex dependence of spontaneous risk, not modified by the screening procedure, can be presented as crude rates for five-year age intervals. Besides, provided fixed gender, the same dependence can be parametrically presented as follows [9]:

\[ \lambda(a, \theta) = \exp(c + p \ln(a) + s I(c)) \]

\[ I(c) = \begin{cases} 0 & \text{for } c < 1992 \\ 1 & \text{for } c \geq 1992, \end{cases} \]

where \( \theta = (c, p, s) \) is the vector of parameters in which \( s \) – describes the modifying screening effect thus that \( \ln(s) \) just is the screening factor; \( c \) – is calendar year; \( a \) – is the attained age in years, \( \lambda(a, \theta) \) – is the incidence rate in cases per person per year.
In dependence (1), taking into account the annually registered number of cases and cohort size, we estimate the vector of parameters $\theta^*$ by applying the maximum-likelihood method within the Poisson regression model. Uncertainty of $\theta^*$ was calculated by inverting the appropriate Fisher matrix.

To engage in comparative analysis, we use register data from foreign countries [3,4]. To conduct comparative analysis on incidence, we used age-standardized incidence rates (ASR) and the standard population used is the World Standard Population [4]. To calculate summary rates for Ukraine we used age and sex distribution of the Ukrainian population according to the 1989 Census [7].

Results
The estimates for parameters (with their 90% confidence intervals) of background risk function (1), not modified by the screening effect, are given in Table 2.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Estimate, [90% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>$-18.8 \quad [-21.1; -16.5]$</td>
</tr>
<tr>
<td>Female</td>
<td>$-19.8 \quad [-21.8; -17.9]$</td>
</tr>
<tr>
<td>Both</td>
<td>$-19.5 \quad [-21.0; -18.0]$</td>
</tr>
</tbody>
</table>

Screening coefficient $\ln(s)$, calculated for both sexes within the populations of subsets (a), (b) (c) attained 0-10 years, amounted to 1.27 with 90% CI [0.63; 2.56].

Table 3 presents comparison of summary background rates, calculated for Ukraine using the fitted model (1), with those in certain European countries [3,4].

Conclusions
In Ukraine, estimates of age and sex-dependent thyroid cancer background risk evidence that since 1992 the enhanced screening for this disease has not affected considerably the levels of background incidence. Coefficient of screening effect accounts for 1.27 with the 90% confidence interval ranging around 1 [0.63; 2.56].

The obtained estimates for parameters of background incidence model in Ukraine allow calculating summary background rates for different age groups (see Table 3). ASR World for Ukraine in 1986-1991 are similar to those for ENGLAND & WALES 88-90 [7]. Sex ratio of
incidence rate for UKRANE 86-91 equaled to 1.8, 2.3 and 3.1 for populations 0-14, 0-19 and 0-29 years old respectively.

Excess thyroid cancer incidence, caused by the Chernobyl accident, of those exposed during childhood (0-18 year-olds as of the time of exposure) markedly increases to the focus of the Chernobyl accident and features considerable dependence on thyroid exposure level. In Ukraine, 1017 thyroid cancer cases among 0-18 year-olds as of the time of the accident were registered in 1990-1997, that is after minimum latent period. Out of this total, 558 cancer cases are treated as background cases and the remaining 459 - as excess cases.

Fig.1. Background and excess thyroid cancer incidence rates in Ukrainian regions (birth cohorts 1968-1997 in the period of 1990-1997)

Acknowledgements
This study was supported by the INCO-COPERNICUS project IC15CT960306 of the European Commission and by Ministry of emergency situations of Ukraine. We want to thank our collaborators P.Jacob, W.F.Heidenreich and G.Goulko from GSF-Institut für Strahlenschutz for constant friendly cooperation.

BIBLIOGRAPHY


THE LONG-TERM EFFECT RISKS, CAUSED BY THE CHORNOBYL ACCIDENT, TO MAN AND ANIMALS

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ABSTRACT
The death rate risks, caused by diseases of tumor and non-tumor genesis, were analyzed in animals permanently living in the Chornobyl exclusion zone. Radioactive loads were formed due to the income of the main dose-forming radionuclides from the Chornobyl accident with forage, water and low-level external radioactivity background. The value of the total absorbed dose of external and internal irradiation was 0.21 Gy. Investigations of analogous indices in animals under conditions of single external total irradiation with $^{60}$Co in a dose of 2 Gy were carried out. It was established that long-term irradiation of animals per unit of absorbed dose caused by incorporated radionuclides, pursuant to the studied indices, was more effective than a single external dose. Typical of the constantly irradiated animals is a decrease in their lifetime, a shift in origination of diseases (especially, in terms of blastomas) in their early age. The dynamics of diseases was studied for a long period (10 years before and 10 years after the Chornobyl accident) in the adult population who have permanently lived in localities with different levels of soil contamination caused by radionuclides. The aim of this investigation was to compare the results of experimental and epidemiological observations. The rate of diseases of endocrine and blood circulation systems have increased, and this correlates with the radiation dose. The risks of illnesses under conditions of influence of radiation in small doses were calculated for the following diseases: diabetes mellitus, hypertension, ischemic disease of heart, myocardial infarction, stenocardia. The role of population stress in an end-stage effect is discussed herein.

A harmful effect on biological objects of the radiation factor of the Chornobyl origin, as well as the connection therewith of the aggravation of the condition of health among the population subjected to a chronic radiation effect in the areas contaminated with radionuclides, brings about a broad discussion.

The aim of the present paper is to determine the risks of:
- origination of remote effects in laboratory animals permanently kept in the ChNPP exclusion zone at controlled radiation doses, as well as in those exposed to a single irradiation;
- excess rate of illness in the population residing in the territories contaminated with radionuclides.

The experimental investigations were carried out with the use of laboratory rats of no breed and rats of the Vistar line. Animal Group I (1,870 animals) was permanently kept, through the lifetime, at the experimental base in the town of Chornobyl at the radiation doses which were formed at the account of an increased external background and internal irradiation caused by the incorporated radionuclides $^{134,137}$Cs and $^{90}$Sr + $^{90}$Y which were supplied to the organism with food. The total dose taken from external and internal irradiation amounted to 21 cGy during the course of life. Animal Group II (980 animals) was totally one-time exposed to $\gamma$-quanta of $^{60}$Co in a dose of 200 cGy, at irradiation power of 7.68 cGy · min$^{-1}$. Animal Group
III (730 pieces) was under an intact control. The animals of Groups II and III were permanently staying at the vivarium of the Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the National Academy of Science of Ukraine (Kyiv).

Applying conventional methods, in the experimental animals of Groups I, II and III, the dynamics of early morphological and biochemical changes, condition of the immune and hematopoietic systems, disease incidence of a tumoral and non-tumoral genesis, and the length of life were studied.

The experimental data obtained allow to state the following:

In the animals of Group II, early changes were developed and remote effects were observed pursuant to the well-known classic data described in literature, with no signs of radiation sickness.

In the animals of Group I, were observed significantly manifested morphological changes and ultra-structural disturbances in various organs and tissues of the organism which manifested in the development of dystrophic, hyperplastic and neoplastic processes on the background of disturbance in blood supply to tissues, which resulted in the rise of the possibility of the development of neoplasia. Established were disturbances of medullary hemopoiesis, reduction of its base, an increase in anemia, lowering of antitumoral resistance of the organism and an increase in malignant diseases of hemopoietic system. A strong disturbance of homeostasis of bone marrow cells was revealed, which indicates the inferiority of the hemopoietic, immune and microcirculatory functions. In the animals of this group, a state of combined immunodeficiency was diagnosed. Overloading of some compensatory reactions results in presenilation of the immune system.

In the irradiated animals, a decrease in the latent period of death caused by diseases of non-tumoral genesis by 3 and 9 months, respectively, for the animals of Groups II and I and reduction of an average lifetime by 2.5 and 8 months were observed. In the exposed animals (especially, in those of Group I), tumors appeared sooner, they were greater in number, the tumors originated at a younger age, polyneoplasia was observed in a considerable number of tumor carriers.

Table 1 presents the risks of death and tumor formation that determined by as, in the animals of the groups under investigation.

Table 1. Risks of death of animals from diseases of non-tumor genesis and formation of tumors in the exposed rats during an average lifetime of the control animals

<table>
<thead>
<tr>
<th>Animal group</th>
<th>Death</th>
<th>Number of tumor carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Nature of irradiation</td>
<td>Permanent</td>
<td>Single</td>
</tr>
<tr>
<td>Source of radiation</td>
<td>Radionuclides from Chornobyl release</td>
<td>γ-quanta of $^{60}$Co</td>
</tr>
<tr>
<td>Total dose per animal, mGy</td>
<td>210</td>
<td>2,000</td>
</tr>
<tr>
<td>Risks, mGy</td>
<td>0.46</td>
<td>0.48</td>
</tr>
<tr>
<td>Double-effect dose, mGy</td>
<td>16.4</td>
<td>159.0</td>
</tr>
</tbody>
</table>

The results of experimental investigations, carried out on animals at the given radiation doses, allow to conclude that the long-term irradiation from external and internal components at the account of the basic dose-creating radionuclides from the Chornobyl release causes substantially greater risks of diseases of tumor and non-tumoral genesis than single external exposure to a much higher dose of radiation.
The epidemiological investigations were dedicated to the analysis of the rate of illness among the adult population in the areas influenced by the Chornobyl accident, as to the main classes of diseases during the last 20 years, beginning from 1977, and to calculations of risks of appearance of additional diseases of various nosology, according to the irradiation doses. Statistical reports of medical establishments were used as initial data for the analysis. A procedure was developed which made it possible to evaluate the contribution of the radiation factor to the growth of the sickness rate at quite low levels of a radiation effect. It includes the following items:

- Selection of representative groups of population, homogeneous in both social and age aspects, compactly residing in the territories differing essentially (several times) in the level of contamination with radionuclides (cesium, strontium). The groups should be identical in all respects: by lines and methods of economic activities, living conditions, mentality; conditions of external unfavorable effects: influence of stressogenic factors, the factors of chemical nature, etc., as well as quantitative and qualitative levels of medical care.

- Analysis of dynamics of sickness rate by separate nosological units for the population groups under comparison. The curves of change of the sickness rate therewith should be brought into the form allowing for their mathematical description.

- Selection of nosological units according to which the growth in the sickness rate correlates with the intensity of the radiation effect.

- Calculation of the actual additional quantity of sickness cases initiated by a radiation effect, in terms of separate kinds of diseases.

- Calculation of risks of origination of additional sickness cases of various nosology under the given conditions of radiation exposure.

Three health localities taking care of the inhabitants of the populated areas with different levels of radioactive contamination of soils were chosen for the comparative analysis:

- The Oster health locality provides medical care for the town of Oster and 15 rural inhabited centers. The total number of adult population amounted, in 1986, was 13,780 people. The level of soil contamination with cesium is equal to 25±10 kBq/m².

- The Kozelets health locality provides medical care for the town of Kozelets and 36 rural inhabited centers with the total number of adult population equal to 18,120 people. The level of soil contamination with radioactive cesium comes to 10.5±5.5 kBq/m².

- Ichniansky rayon of Chernihivska oblast (control). The adult population of 44,675 people, the level of soil contamination with cesium does not exceed 3.7 kBq/m².

The living conditions of all the population groups are close with respect to all the indices, including the stress factor effect.

It has been established that annual incidence of various types of diseases in the post-Chornobyl period is subject to considerable variations, therefore the disease incidence curve was faired. Thereafter, the pre-accident trend of growth of incidence of the given etiology was determined, and the predicted indices of a spontaneous level were deducted from the actual values, with allowance made for the curve fairing (see Fig. 1). By application of this procedure, the disease incidence, caused by chemical and other long-acting harmful factors characteristic of the given locality, was automatically deducted. Thereafter, a mathematical description of the additional disease incidence function was provided, and absolute risks of origination of extra quantity of disease incidence and relative risks per a unit of collective
The actual curve
- the curve after fairing
- the pre-accident a trend

Fig. 1. Illustration of mathematical processing of the results of investigations.

As a result of processing of the data of epidemiological examinations, it was established that there exists a correlative relationship, for the adult population residing in the territories contaminated with radionuclides, between the levels of radiation effect and origination of an additional diseases of vascular system (hypertension, ischemic disease of heart, myocardial infarction, stenocardia), as well as endocrine system (diabetes mellitus). No relationships were revealed between other diseases incidence and the radiation factor influence under the given conditions of radiation exposure. The results of calculations of the risks are shown in Table 2.

Table 2. Risks of origination of additional disease incidence in the population groups under examination.

<table>
<thead>
<tr>
<th>Health locality</th>
<th>Average effective dose, mSv</th>
<th>Collective dose, person-Sv</th>
<th>Nosological units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oster</td>
<td>13.2±1.5</td>
<td>172.0±18.0</td>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hypertension</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ischemic disease of heart</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stenocardia</td>
</tr>
</tbody>
</table>

The numerator shows the absolute risk of origination of additional disease incidence; the denominator presents a relative risk per 1 person-Sv of the collective dose. It is expected that the present values of risks are valid only at a combined long-term effect of low-level ionizing radiation and chronic stress.
EPIDEMIOLOGICAL INVESTIGATION HEALTH STATUS OF CHILDREN EXPOSED TO THE CHERNOBYL ACCIDENT

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ABSTRACT
The most important, high risk group among victims Chernobyl disaster is the group of children who were evacuated from Chernobyl's zone.
Objective: to investigate health status of children exposed to Chernobyl accident; to level psycho-social status among these victims; to evaluate negative psychological status as risk factor for somatic disorders.
Cohort. Evacuated in April 1986 from contaminated Chernobyl's zone children 3165 were followed up from 1989 till 1998.
Methods. The annual clinical observation program includes: medical observation (physical examination; biochemical and hematological analysis; ultrasound of thyroid gland and abdomen), psycho-social observation (Spielberger trait-state anxiety scale; Eysenck neuroticism scale; sentence completion test; GHQ-12), social observation for parents. Data was analyzed using Epilnfo-6 with confidence interval 95 %. For coding ICD-9 was used.
Results. The observation about the health status victims reveals negative changes. Prevalence all diseases dramatically increased (5890.6 % - 1989 to 9227.3 % - 1998). Relative risk in comparison with same age Ukrainian children for most important disorders is: peptic - 6.4; cardiovascular - 5.1; nervous system - 6.3; immune - 5.3. The GHQ-12 result > 4 is risk factor for peptic disorders (4.3), cardiovascular disorders (5.2), nervous system disorders (3.2). Many children had fatality mood, expecting cancer outcomes for themselves and their family. In 1997-98 they hid that they belonged to suffering population in expecting discrimination in further education, work, marriage.
Conclusions. The situation with somatic health and psychological status of the children who were evacuated from Chernobyl zone is considerable worse in comparison with Kiev children. Children victims Chernobyl disaster are at risk for psychosomatic disorders. Peptic, cardiovascular and nervous system disorders are especially connected with emotional stress.

INTRODUCTION
The Research Center for Radiation Medicine (RCRM) was created in October 1986 for investigation medical effects after Chernobyl disaster. The Laboratory Children Population Health, where this study was conducted, is a part of the Epidemiology Department of the RCRM.
The international studies, including IPHECA WHO, verified as radiation induced only an increase in the incidence of thyroid cancer among children victims Chernobyl disaster (1). But many epidemiological investigations described about increasing in rates notcancer, somatic diseases in dynamic (2).
Several cross-sectional studies conducted among affected populations have demonstrated a relatively high prevalence of psychological distress as compared to non-affected control groups (3, 4).
OBJECTIVE: to investigate health status of children exposed to Chernobyl accident; to level psycho-social status among these victims; to evaluate negative psychological status as risk factor for somatic disorders.
SUBJECTS AND METHODS. The most important, high risk group among victims of the Chernobyl disaster is the group of children who were evacuated from Chernobyl's zone. Evacuated in April 1986 from contaminated Chernobyl's zone, 3165 were followed up from 1989 till 1998.

The annual clinical observation program includes: physical examination, biochemical and hematological analysis, ultrasound of thyroid gland and abdomen, psychological tests for children, social observation for parents. For children 13-17 GHQ -12 was used. The data sources are: National Register of Ukraine, district Hospitals, Clinical Register of RCRM.

Data was analyzing using EpiInfo-6 with confidence interval 95 %. Observation included the period from 1989 to 1998. For coding ICD-9 was used.

RESULTS. The annual observation about the health status of evacuated from Chernobyl's zone children reveals negative changes. The prevalence all diseases increased (Figure 1). The prevalence all diseases increased in such part as digestion organ diseases, cardiovascular diseases, diseases nervous system.

![Figure 1. Prevalence (‰/000) all diseases among evacuated children](image)

The comparison of the annual amount all diseases showed negative dynamic among children who were evacuated from Chernobyl's zone and biological variability among same age Kiev children (Figure 2). Relative risk (1999 data) in comparison with same age Ukrainian children for most important disorders is: peptic - 6.4; cardiovascular - 5.1; nervous system - 6.3; immune - 5.3 (Figure 3).

The result of GHQ-12 observation is presented on the table 1. The high score and middle score results are more prevalent among 16-18 age groups. The high score is more prevalent among 16 - 18 years old girls. The annual amount of all diseases is higher among children with high score GHQ-12 result as in 13-15 age groups as in 16-28 age groups (Table 2). The GHQ-12 result > 4 is risk factor for peptic disorders (4.3), cardiovascular disorders (5.2), nervous system disorders (3.2).
Figure 2. Annual amount all diseases %00 among evacuated children and coevals
Figure 3. Relative risk some diseases among evacuated children

![Graph showing relative risk of diseases among evacuated children over the years 1992 to 1998.]

Table 1. Distribution (%) evacuated children according the GHQ-12 result (1998 data)

<table>
<thead>
<tr>
<th>GHQ-12</th>
<th>13 - 15 years</th>
<th>16 - 18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>boys</td>
<td>girls</td>
</tr>
<tr>
<td>0 - 1</td>
<td>95.9</td>
<td>96.7</td>
</tr>
<tr>
<td>2 - 3</td>
<td>2.2</td>
<td>1.7</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>1.9</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Table 2. Annual amount all diseases (‰) among groups (1,2,3) according the GHQ-12 result (1998 data)

<table>
<thead>
<tr>
<th>Group</th>
<th>GHQ- 12</th>
<th>age 13 - 15 years</th>
<th>age 16 - 18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - 1</td>
<td>%/000</td>
<td>%/000</td>
</tr>
<tr>
<td>1</td>
<td>0 - 1</td>
<td>28140</td>
<td>32170</td>
</tr>
<tr>
<td>2</td>
<td>2 - 3</td>
<td>34120</td>
<td>33163</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 4</td>
<td>54126</td>
<td>59301</td>
</tr>
</tbody>
</table>

Many children had fatalistic mood, expecting cancer outcomes for themselves and their family. In 1997-98 they hid that they belonged to suffering population in expecting discrimination in further education, work, marriage.
DISCUSSION. The observations in this study indicate that the situation with somatic health and psychological status of the children who were evacuated from Chernobyl's zone is considerably worse in comparison with Kiev children. The result of the observation evacuated children showed stable negative dynamic during all period after disaster. The prevalence all diseases had increased, especially diseases of the digestive tract, cardiovascular diseases and diseases of the nervous system. Many scientists described the same dynamic among victims as children as adult age populations (1, 2). The international studies, including IPHECA WHO, verified as radiation induced only an increase in the incidence of thyroid cancer among children victims Chernobyl disaster (1).

Our previous investigations show that all children victims Chernobyl disaster are at risk for psychosomatic disorders (5). Medical and psychological observations conducted among affected children populations have demonstrated a high prevalence of psychological distress in comparison to non-affected control groups (6).

Psychosomatic health promotion and social rehabilitation programs with taking into account dynamic in psychological and social situation among evacuated children will minimize significantly impact after Chernobyl for this population victims.

CONCLUSIONS. The situation with somatic health and psychological status of the children who were evacuated from Chernobyl's zone is considerably worse in comparison with Kiev children. Children victims Chernobyl disaster are at risk for psychosomatic disorders. The 16-18 aged evacuated girls are most high risk group for psychological and somatic problems. Peptic, cardiovascular and nervous system disorders are especially connected with emotional stress.

REFERENCES
Here we appreciated the radiation risk of death from radiation-induced cancer caused by an exposure owing to accident on Chernobyl NPP for various groups of an injured population: all population of Ukraine; the population evacuated from 30-km zone; the relocated people from zones of radioactive contamination, since 1990; the liquidators of consequences of accident (LCA) on Chernobyl NPP of 1986-1987 years. Also we carried out the comparison of radiation risks from exposure sources of an accidental and natural origin. Is shown that only for LCA persons the risk of death from radiation-induced cancer owing to accidental exposure (0.0127) exceeds appropriate risk from sources of a natural origin (0.00272).

We estimated the risk of disease by a thyroid cancer for persons of different groups obtaining exposure doses from radionuclides of iodine. The relation of an expected amount of cases of disease by a thyroid cancer owing to accidental exposure with a spontaneous level of disease in Ukraine is shown. Only for children of most polluted areas is expected more than repeated magnification of an amount of cancer. For all remaining groups of the population the component is insignificant and hardly definable on a hum noise of oscillations of a spontaneous level.
RADIATION RISKS AT LOW DOSES OF EXPOSURE: LESSONS OF CHERNOBYL

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Medical Radiological Research Center of Russian Academy of Medical Sciences, 4 Korolev Street, Obninsk 249020, Russia; Phone: +7-095-956-9412; Fax: +7-095-956-14-40; E-mail: nrer@obninsk.ru

ABSTRACT

20th century which can be called as the century of atomic energy in terms of its application for peaceful and military purposes is coming to its fall. It is reasonable to know risks of radiation exposure for health status of population. Findings of long-term epidemiological studies in Japan commenced after the atomic bombings of Hiroshima and Nagasaki in 1945 allowed one to make statistically reliable assessments of radiation risks for induction of malignant diseases. However, the assessments derived from direct epidemiological studies (LSS study) confirmed increase in cancer incidence and mortality rate among A-bomb survivors at the level of middle and high radiation doses (more than 0.5 Sv). The made estimates were further used in ICRP recommendations.

After the Chernobyl catastrophe the most of exposed persons received low doses (less than 0.2 Sv). For epidemiological analysis of health effects of the Chernobyl catastrophe in Russia personal data of National registry on 530 thousand of individuals including 174 thousand of liquidators were used. Mean external radiation dose to liquidators is 0.11 Gy. In 1998 cohort epidemiological studies were completed. Their results allowed one to assess radiation risks for leukaemia, except for CLL, at low doses of exposure: ERR/Gy is 9.9 (95% CI: 1.1, 18.6).

INTRODUCTION

In June of 1986 (in two months after the Chernobyl catastrophe) Ministry of Health of the USSR and Academy of Medical Sciences of the USSR made decision on setting up All-Union distributed registry (AUDR) for persons exposed to radiation. Research Institute of Medical Radiology of Academy of Medical Sciences of the USSR (now it is Medical Radiological Research Center of Russian Academy of Medical Sciences) was designated as heading institution responsible for setting up and managing AUDR.

Two basic tasks should be solved by the staff of the institute:

• prompt information support for making managerial decisions at the level of the Ministry of Health of the USSR towards minimisation of consequences of the catastrophe;
• support for long-term radiation-epidemiological studies and identification of radiation and non-radiation factors modifying risk (similar work was performed within frames of the registry of atomic bombing survivors in Hiroshima and Nagasaki).

The registry had been operating until 01.01.1992 (time of dissolution of the USSR). Information on 659 thousand individuals exposed to radiation including 285 thousand recovery workers of the Chernobyl catastrophe had been collected and analysed.

At present time Russian National Medical and Dosimetric Registry (RNMDR) is operating at MRRC RAMS (Obninsk) under Enactment of the Government of the Russian Federation N 948 of September 22, 1993 and Orders of the Ministry of Health of The Russian Federation and Russian Academy of Medical Sciences. Individual information on 531 thousand persons including 174 thousand emergency accident workers ("liquidators") is stored at the registry.
We present basic results of the studies of radiation risks for leukaemia and solid cancer incidence among liquidators obtained in 1998.

RELATIONSHIP BETWEEN RADIATION DOSE AND LEUKAEMIA INCIDENCE

Risk for radiation-induced cancers is maximal for leukaemia, latent period for it is minimal, 2 years. The first analysis for leukaemia radiation risks for liquidators of Russia was made in 1996 [1, 2]. In paper [1] authors applied cohort technology to the study, the population of Russia stratified by sex and age was chosen as control group. Information on 48 leukaemia cases among male liquidators detected over 1986-1993 was analysed. Excess of leukaemia incidence among liquidators over control is statistically meaningful. Standardised incidence ratio for liquidators is 1.5 (95% CI: 1.1, 2.0). Radiation risks of leukaemia was assessed on the assumption that the excess was caused by radiation. Magnitude of excess relative risk (ERR/Gy) is 4.3 (95% CI: 0.8, 7.8).

In paper [2] authors used case-control technology. In the study statistically meaningful risks were not found, however the tendency towards relation of relative risk to dose was shown.

In the presented work the analysis of new data on leukaemia incidence among liquidators is given. For the period over 1993-1996 distribution of leukaemia cases by various reasons has changed: newly diagnosed cases and newly reported cases were added, diagnosis for some cases and date of its ascertainment was verified. Detected number of leukaemia cases allow us to analyse them with the use of the most reliable medical and dosimetric data. In the analysis medical and dosimetric data from 6 regional centres of Russia (Severo-Zapadny, Volgo-Vyatksy, Povolzhsky, Centralno-Chemoziomny, Severo-Kavkazsky and Uralsky) were used.

The size of the cohort under study is 93849 individuals, of them 68199 persons have authorised doses recorded in documents.

Number of person-years for the period of follow-up was 903230 (648917 PY with authorised doses). Mean dose to a liquidator with authorised doses is 0.11 Gy. Mean age at arrival at 30-km zone around the Chernobyl accident is 32.4 years.

To estimate coefficients for radiation risk of leukaemia incidence 22 cases with verified diagnosis were considered. Individual doses of external exposure to these cases are kept at RNMDR. Set of data used for estimation of coefficients for risks by methods of maximal likelihood is given in table 1.

Table 1. Set of data used for estimation of dose-response relationship for leukaemia incidence (all types of leukaemia).

<table>
<thead>
<tr>
<th>Dose group</th>
<th>Number of PY of follow-up</th>
<th>Number of cases</th>
<th>Mean dose (Gy)</th>
<th>Mean age of cases at exposure</th>
<th>Mean age of cases at diagnosis</th>
<th>Mean age of all liquidators at exposure</th>
<th>Mean age of all liquidators at diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>154226</td>
<td>5</td>
<td>0.02</td>
<td>32.6</td>
<td>37.0</td>
<td>34.5</td>
<td>42.7</td>
</tr>
<tr>
<td>2</td>
<td>211726</td>
<td>5</td>
<td>0.08</td>
<td>31.9</td>
<td>39.1</td>
<td>34.8</td>
<td>43.4</td>
</tr>
<tr>
<td>3</td>
<td>170453</td>
<td>6</td>
<td>0.16</td>
<td>31.9</td>
<td>39.5</td>
<td>34.9</td>
<td>44.2</td>
</tr>
<tr>
<td>4</td>
<td>111074</td>
<td>6</td>
<td>0.23</td>
<td>35.6</td>
<td>44.4</td>
<td>34.3</td>
<td>43.9</td>
</tr>
</tbody>
</table>

At present time chronic lymphatic leukaemia (CLL) were not proved can be caused by radiation. That is why all types of leukaemia except for CLL (5 cases) were taken in the study of dose-response relationship. Data used for calculation of risk coefficients are given in table 2.
Relationship between incidence rate and dose is shown in figures 1, 2. Estimates for risk coefficients for all types of leukaemia is shown in table 3. Obtained results show that coefficients for risk for all types of leukaemia are not meaningful. When CLL is set off risk coefficients are statistically meaningful.

Table 2. Set of data used for estimation of dose-response relationship for leukaemia incidence (except for CLL).

<table>
<thead>
<tr>
<th>Dose group</th>
<th>Number of PY of follow-up</th>
<th>Number of cases</th>
<th>Mean dose (Gy)</th>
<th>Mean age of cases at exposure</th>
<th>Mean age of cases at diagnosis</th>
<th>Mean age of all liquidators at exposure</th>
<th>Mean age of all liquidators at diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>365952</td>
<td>7</td>
<td>0.05</td>
<td>31.7</td>
<td>38.4</td>
<td>34.7</td>
<td>43.1</td>
</tr>
<tr>
<td>2</td>
<td>170453</td>
<td>5</td>
<td>0.15</td>
<td>35.6</td>
<td>42.2</td>
<td>34.9</td>
<td>44.2</td>
</tr>
<tr>
<td>3</td>
<td>111074</td>
<td>5</td>
<td>0.23</td>
<td>34.2</td>
<td>43.3</td>
<td>34.3</td>
<td>43.9</td>
</tr>
</tbody>
</table>

Fig. 1. Dose-response relationship for leukaemia incidence (all types of leukaemia) among liquidators.
Fig. 2. Dose-response relationship for leukaemia incidence (except for CLL) among liquidators.

Table 3. Estimates for risk of radiation-induced leukaemia in cohort of liquidators.

<table>
<thead>
<tr>
<th>Risk</th>
<th>All types of leukaemia (95% CI)</th>
<th>All types of leukaemia except for CLL (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAR [$10^{-4}$PY Gy$^{-1}$]</td>
<td>0.9 (-0.3, 2.0)</td>
<td>1.2 (0.1, 2.3)</td>
</tr>
<tr>
<td>ERR/Gy</td>
<td>3.7 (-1.7, 8.4)</td>
<td>9.9 (1.1, 18.6)</td>
</tr>
</tbody>
</table>

REFERENCES
COMPARISON OF CS-137 AND SR-90 CONTENTS IN SURFACE, GROUND AND UNDERGROUND WATERS OF POLLUTED AREAS OF "NEAR" AND "DISTANT" ZONES OF CHERNOBYL TRACE WITH THEIR CONTENT IN SOIL-GROUNDS.

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The laboratory of Radiobiology of Water Systems studies the radionuclides behaviour in water environment since 1988 in small rivers of Sozh, Pripyat and Neman basins.

The qualitative composition of waters in small rivers is mainly formed under the influence of physico-geographical situation, antropogenie factors, underground waters (especially in summer and winter dry season) and their hydrological connection with ground waters of upper horizon and of the deep seam as well.

The aim of this work was to reveal the dynamics of behavior and re-distribution of Cs-137 and Sr-90 between the components of water ecosystem (water, water suspensions, bottom deposits) and of their quantitative correlations with ground and underground waters as well as in soil-groounds of water collection areas adjacent to waterflows.

The basis of methodology of study was concluded in the regular annual radioecological examination of surface and ground waters on landscape-geochemical plots situated in natural and antropogenic ecosystems with different densities of superficial radioactive pollution of water collection areas.

As a result of studies it was established that the increase of radionuclides content by the course of river is characteristic for rivers Braginka, Nesvich, Slovechna wich drain the most polluted areas of 30-km zone of ChNPS. In 1997, the radionuclides content in rivers Slovechna, Nesvich, Braginka increased from 0,55 to 0,65; from 0,56 to 0,65; from 0,38 to 0,56 for Cs-137 and from 0,1 to 0,12; from 2,5 to 2,9 and from 0,21 to 2,0 Bq/l for Sr-90 respectively. Whereas such dependence is not observed in rivers Lipa and Senna (Sozh basin). The excess of Sr-90 content over the content of Cs-137 is characteristic for river Senna. For example, the Cs-137 content in autumn of 1997 near v.Chudjany was 0,15 Bq/l and Sr-90 - 0,29 Bq/l. The Cs-137 content in Lipa river is higher 3-10 times than that of Sr-90.

For the "distant" from ChNPS zone in Grodno, Minsk and Brest regions the Cs-137 content in the majority of cases is 1,5-12 times as high as that of Sr-90. Only in samples of water from Dedik, Moroch, L'va, Sluch rivers the Sr-90 content exceeds the Cs-137 content 1,2-1,5 times and is situated within the limits of 0,068 and 0,091 Bq/l for Cs-137 and Sr-90 respectively.

In ground water of both "near" and "distant" zones (wells) the radionuclides content is something lower than in surface water. There are cases however when the radionuclides content in ground water exceeds their content in surface water (river Goryn'- 07.1997: the Cs-137 and Sr-90 contents are respectively 4 and 2 times higher). In river L'va, v.Olmanï (07.1997), the Cs-137 and Sr-90 content in ground water is respectively 30 and 3 times higher than that in surface water. In river Lipa, v. Andreevka (10.1997), the Sr-90 content in ground water is 1,4 times as high as that in surface ground water is 1,2 times as high as that in surface water. The excess of radionuclides content in ground waters of "distant" zone of Minsk, Brest...
and Grodno regions over their content in surface water is also registered.

The comparison of radionuclides content in surface water and water collection wells shows that the Cs-137 and Sr-90 content in all wells is lower than in surface water.

For potable water supply, the waters of Paleogenic and Cretaceous deposits are mainly used in Gomel region, and in Mogilev region - waters of Devonian deposits which are closely hydraulically connected with waters of Quaternary and subjacent deposits. The Cs-137 content in them is not higher than 0.059-0.05 and 0.062-0.079; 0.114; 0.087-0.105 Bq/l, and Sr-90 - 0.022-0.027 and 0.024-0.046; 0.091; 0.073-0.085 respectively by given deposits.

In soil-grounds of "near" zone the Cs-137 content is mainly higher than Sr-90 content 2-10 times. However the Sr-90 content, e.g. in villages Kozhushki, Tamozhnya, Gden', Bragin, Malinovka - 1.5; 4.0; 1.2; 1.3 times respectively. The analysis of radionuclides distribution by the depth of profile showed that the radionuclides are situated mainly in 10-sm layer of soil, e.g. 56% of Cs-137 and 88% of Sr-90 in v. Kulazhin are situated in the upper 10-sm layer of soil.

The analysis of radionuclides content in soil-grounds of "distant" zone (Minsk, Brest, Grodno regions) has shown that the Cs-137 quantity in the majority of samples is 1.2-73 times as high as that of Sr-90. However there are samples where the Sr-90 content is higher than the Cs-137 content is higher than the Cs-137 content 3.7;1.3;16.3 times - on sites Naroch, Myastro, Vilija, Yanushkovichi, Morino. The analysis of comparison of radionuclides content by soil profile has shown that the main quantity of Cs-137 is situated in 10-15-sm layer of soil. However some sites were registered where the Cs-137 content was practically equal by all soil profile (v. Gavr'ilchitsy - from 38 to 30 Bk/kg up to the depth of 50-sm - mineral soil), and on 50-sm depth in peat soil the Cs-137 content its content in 10-sm layer 5 times and constitute 233 Bq/kg (Fig. 1). The Sr-90 content in mineral soil is practically even from 15-sm layer and constitutes 84 Bq/kg meanwhile 5<15 Bq/kg is situated in the upper 10-sm layer, i.e. 6.1% of its content in the lower layer or 5.8% of its whole content in the ground. Sr-90 is distributed practically evenly by all profile in peat soil and its total content constitutes 245 Bq/kg. On the site near v. Olmany (Fig. 2) (r.L'va) on the bank of river the Cs-137 is mainly situated in 5-sm layer of soil and constitutes 79% of its total content (1327 Bq/kg) in pillar, however its content has constituted 127 Bq/kg on the water-repellent layer (clay) on 50-sm depth. In soil sample picked up at 60-m distance in a forest the Cs-137 content is 6450 Bq/kg. 75% of its total content is situated in the upper layer, and 732 Bq/kg or 11% of its quantity in pillar is situated on 50-sm depth (on the barrier). In terms of distribution by the depth of profiles, Sr-90 on river bank and in forest is mainly situated on the barrier (88% in first and 92% in second case).

CONCLUSIONS

1. Cs-137 content surface water of waterflow has decreased considerably as compared with initial stage of observation in all waterflows. And Sr-90 content in surface water of certain sites has increased considerably testifying thus to the increased migration ability of its new compounds.

2. The migration properties of Cs-137 in "distant" from ChNPP zone increased significantly as compared with the migration properties of Cs-137 precipitated in "near" zone. This is confirmed by the fact the Cs-137 content in ground water of sites situated in "Distant"
3. The Cs-137 and Sr-90 migration depends on sorption properties of soil-ground, and-in favourable circumstances - both Cs-137 and Sr-90 penetrate to the 50-cm depth and concentrate on sorption barrier such layers as it is in given case.

Fig.1 The distribution of $^{137}$Cs and $^{90}$Sr by the depth of soils v. Gavrilchicy, Riv.Lan’.

Fig.2 The distribution of $^{137}$Cs and $^{90}$Sr by the depth of soils vil. Ol’many, Riv.L’va.
RESULTS OF THE 10-YEARS STUDY OF LEUKEMIA IN
CHERNOBYL ACCIDENT CLEAN-UP WORKERS IN UKRAINE

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1Ministry of Energy of Ukraine
2Research Center for Radiation Medicine of Ukraine

ABSTRACT
The study was made to determine whether the leukemia incidence rate in Chernobyl NPP
clean-up workers catastrophe depended on the year of the emergency work and the period
after irradiation.
The analysis was done for liquidators of 1986 and 1987 by periods of observation of 1987-
Leukemia relative risk in liquidators of 1986 versus liquidators of 1987 in 1987-1991 was
defined at the level of 3,32 (1,08; 10,20). Combined Leukemia and Relative Disorders
relative risk in liquidators of 1986 versus liquidators of 1987 in 1987-1991 was defined at the
level of 4,15 (1,24; 13,89). No significant differences were defined in 1992-1996.

1. INTRODUCTION
The leukemia morbidity analysis in irradiated persons first of all in atomic bomb survivors (1,
2) showed that the leukemia risks excess would be observed in population suffered after the
Chernobyl accident.

2. MATERIALS AND METHODS.
2.1 Population group under study.
The male clean-up workers who are registered at the Ukrainian State Chernobyl Registry. The
number of persons under study at the end of the observation period is 179 026.

2.2 Period of observation.
The data were collected for the period of 1987-1996 and were analyses by 5-year intervals
Number of person-years was calculated as the sum of average numbers of liquidators
followed up each year. Person-years distribution by age and periods of observation are
presented in tables 1-2.

Table 1. Person-years of observation by age groups (full period, 1987-1996)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>128 470</td>
<td>52 439</td>
<td>4 180</td>
<td>185 089</td>
</tr>
<tr>
<td>30-39</td>
<td>336 877</td>
<td>165 222</td>
<td>111 563</td>
<td>613 662</td>
</tr>
<tr>
<td>40-49</td>
<td>187 467</td>
<td>98 292</td>
<td>93 248</td>
<td>379 007</td>
</tr>
<tr>
<td>50-59</td>
<td>74 242</td>
<td>13 070</td>
<td>4 437</td>
<td>91 749</td>
</tr>
<tr>
<td>60-69</td>
<td>20 021</td>
<td>2 291</td>
<td>568</td>
<td>22 880</td>
</tr>
<tr>
<td>20-69</td>
<td>747 077</td>
<td>331 314</td>
<td>213 996</td>
<td>1 292 387</td>
</tr>
</tbody>
</table>
Table 2. Person-years of observation by periods.

<table>
<thead>
<tr>
<th>Period of observation</th>
<th>Year of clean-up work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992-1996</td>
<td>454 254</td>
</tr>
<tr>
<td>1987-1996</td>
<td>747 077</td>
</tr>
</tbody>
</table>

2.3 Diseases under study.
All the types of acute and chronic leukemia were studied. In addition the combined analysis of leukemia and related disorders (polycytemia, myelofibrosis, myelodisplasia) morbidity was conducted.

Two main sources of information were used to collect the data on cases of the diseases of interest: the results of the routine yearly medical examinations and the data from the regions' hematological clinics. The retrospective and prospective cases were collected with active and passive ways. Data collecting activity was realized due to the active help from the local medical personnel.

All cases were verified and linked to the file of liquidators under study.

2.4 Analytical approach
Age Standardized Rate (ASR) using the world population standard (3) and Standardized Incidence Ratio (SIR) were calculated for liquidators of 1986 and 1987 by analyzed periods.

3. RESULTS AND DISCUSSION.
The data on 71 cases of leukemia and 15 cases of related disorders diagnosed in 1987-1996 were desired to be acceptable for the consequent analysis.

Age distribution of the cases is presented in table 3. Cases distribution by periods of observation is in table 4.

Table 3. Age distribution of the leukemia and related disorders cases diagnosed in liquidators under study in 1987-1996

<table>
<thead>
<tr>
<th>Age group</th>
<th>Diseases</th>
<th>Year of the clean-up work</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>Leukemia</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>1</td>
</tr>
<tr>
<td>30-39</td>
<td>Leukemia</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>3</td>
</tr>
<tr>
<td>40-49</td>
<td>Leukemia</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>5</td>
</tr>
<tr>
<td>50-59</td>
<td>Leukemia</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>3</td>
</tr>
<tr>
<td>60-69</td>
<td>Leukemia</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>2</td>
</tr>
<tr>
<td>20-69</td>
<td>Leukemia</td>
<td>48</td>
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<tr>
<td></td>
<td>Related disorders</td>
<td>14</td>
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</tbody>
</table>
Table 4. Distribution of the leukemia and related disorders cases diagnosed in liquidators under study in 1987-1996 by periods of observation

<table>
<thead>
<tr>
<th>Period of observation</th>
<th>Disease</th>
<th>Year of the clean-up work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-1991</td>
<td>Leukemia</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>2</td>
</tr>
<tr>
<td>1992-1996</td>
<td>Leukemia</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>12</td>
</tr>
<tr>
<td>1987-1996</td>
<td>Leukemia</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Related disorders</td>
<td>14</td>
</tr>
</tbody>
</table>

Among 48 leukemia cases diagnosed in liquidators of 1986: 13 (27 %) are acute leukemia (AL), 20 (42%) are chronic lymphoid leukemia (CLL), 15 (31 %) are chronic myegenous and rare forms(CML). Among 15 leukemia cases diagnosed in liquidators of 1987: 8 (53 %) are AL, 2 (13 %) are CLL, 5 (33 %) are CML and rare forms.

Cases in liquidators of 1988-1990 are the following: 1 acute leukemia case, 4 cases of chronic lymphoid leukemia, 3 cases of chronic myegenous leukemia.

In order to determine whether the leukemia and related disorders incidence rates depended on the year of clean-up work and the period after irradiation the ASR and SIR and their 95 % confident intervals were calculated. The results of SIR calculation are presented in the tables 5-6.

Table 5
Results of Standardized Leukemia Incidence Ratio calculation for liquidators of 1986 versus liquidators of 1987 by periods of observation.

<table>
<thead>
<tr>
<th>Period of observation</th>
<th>SIR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-1991</td>
<td>3.32 (1.08; 10.20)</td>
</tr>
<tr>
<td>1992-1996</td>
<td>0.69 (0.15; 3.05)</td>
</tr>
<tr>
<td>1987-1996</td>
<td>1.00 (0.29; 3.42)</td>
</tr>
</tbody>
</table>

The analysis results presented above, give us an evident tendency of leukemia risks increasing in the liquidators of 1986 in compare with the liquidators of 1987 during the first 5-year period after catastrophe. The most significant rise is observed in 1989-1991 when the SIR is of 4.86 (95 % CI: 1.15 - 20.52)

Table 6
Results of Standardized Leukemia and Related Disorders Incidence Ratio calculation for liquidators of 1986 versus liquidators of 1987 by periods of observation.

<table>
<thead>
<tr>
<th>Period of observation</th>
<th>SIR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-1991</td>
<td>4.15 (1.24; 13.89)</td>
</tr>
<tr>
<td>1992-1996</td>
<td>0.88 (0.26; 2.97)</td>
</tr>
<tr>
<td>1987-1996</td>
<td>1.16 (0.41; 3.29)</td>
</tr>
</tbody>
</table>

The combined analysis of leukemia and related disorders demonstrates more confident differences in liquidators’ of 1986 and 1987 incidence.
The tendencies found could be probably explained by the differences in the level of irradiation in 1986 and 1987 (4). No significant differences were defined in 1992-1996 yy.

3. CONCLUSIONS.
The results of the conducted study indicate the increasing of the leukemia and related disorders incidence in liquidators of 1986 in compare with the liquidators of 1987 during the 5-years period after catastrophe. Further study of the leukemia and related disorders should be carried out using the appropriate dosimetry and analytical approaches to provide more detailed and sufficient risks assessment.

REFERENCES
ABSTRACT
Assessment of stochastic late effects in Belarus as well as in the Ukraine and Russia as a result of the Chernobyl accident is discussed in the paper. The assessment was carried out on the basis of experimental data on exposition dose rates in air, data on internal irradiation of people affected by the accident as well as data on the surface contamination by isotopes discharged from the Chernobyl reactor. Comparison of calculated data on the thyroid cancer morbidity with the number of cancers of this type appeared in the years 1986 – 1997 shows quite reasonable agreement between forecasted and real findings.

INTRODUCTION
It is well known that experts of different countries and different international organisations [1-4] are unanimous in the opinion that the Chernobyl accident has caused enormous socio-economic consequences in Belarus, the Ukraine and the Russian Federation. It is also recognised that residents of the former USSR have been subject to various psychological burdens as a result of the Chernobyl accident. However, many specialists rejected the possibility of serious medical consequences other than psychic stresses and feeling of anxiety suffered by the residents of the affected areas.

The incorrectness of such optimistic prognoses is now evident. So, for example, only 39 additional thyroid cancers for children and 52 for adults of Belarus were forecasted by L.Ilyin et al [4]. This is at least one order in magnitude less than the numbers of additional thyroid cancers that manifested in Belarus in the period from 1986 to 1997: about 560 cases by children and about 2700 cases by adults of Belarus [5].

During the last years more accurate data were established on the total discharge of radioactive species due to the Chernobyl accident, as well as more accurate data on deposition of different radionuclides in the affected areas of the former USSR.

The facts justify any independent analysis of possible medical consequences of the Chernobyl accident.

RESULTS AND DISCUSSION
This paper presents results of our assessment of Chernobyl medical consequences for Belarus published in the report [6].

The following limitations were taken into consideration in our assessment. First, we have restricted our analysis to stochastic effects of ionizing radiation only. Second, we have also included from our analysis members of the personnel of the Chernobyl NPP and the cohort of liquidators. It means that our study was concentrated only on the population of areas affected by the Chernobyl accident.

Different empirical data such as the measured exposition doses, experimental data on radionuclide deposition as well as data on internal irradiation were used in our calculations.

Results of the collective equivalent doses calculation that can be delivered to affected population of Belarus, Russia and the Ukraine within the period of 70 years after the Chernobyl accident are given in Tables 1 and 2. Data on collective equivalent doses in Table
1 include external and internal doses calculated by considering of all isotopes. However, the contribution of isotope iodine-I31 to the collective equivalent doses were assessed separately and is presented in Table 2 as a collective dose equivalent resulted from thyroid irradiation. These Tables also contain data on the total deposition of the isotopes in Belarus, Russia and the Ukraine, as well as the data on the mean contamination levels and mean dose delivered over 70 years on a territory with the contamination level by $^{137}$Cs equal to 1 Ci/km$^2$. The total amounts of $^{131}$I deposited in these countries were calculated by means of the data on $^{137}$Cs deposition presented in Table 1 as well as the following numeric values of factor 10 for Russia and 20 for Belarus and the Ukraine.

Table 1: Collective equivalent irradiation doses of populations of Belarus, the Russian Federation and the Ukraine.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Belarus</th>
<th>Russia</th>
<th>Ukraine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total deposition of caesium-137, Ci</td>
<td>440000</td>
<td>460000</td>
<td>300000</td>
</tr>
<tr>
<td>Mean contamination level, Ci/km$^2$</td>
<td>3,225</td>
<td>1,318</td>
<td>1,168</td>
</tr>
<tr>
<td>Mean dose equivalent commitment during 70 years after the accident (normalized to 1 Ci/km$^2$), rem</td>
<td>0,26</td>
<td>0,26</td>
<td>0,26</td>
</tr>
<tr>
<td>Collective dose in man Sv, rounded</td>
<td>5,5·10^4</td>
<td>4,4·10^4</td>
<td>6,6·10^4</td>
</tr>
<tr>
<td>Mean individual dose, rem</td>
<td>0,84</td>
<td>0,26</td>
<td>0,30</td>
</tr>
</tbody>
</table>

Table 2: Collective thyroid dose of the affected populations in Belarus, the Russian Federation and the Ukraine.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Belarus</th>
<th>Russia</th>
<th>Ukraine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total deposition, Ci</td>
<td>8800000</td>
<td>4600000</td>
<td>6000000</td>
</tr>
<tr>
<td>Thyroid collective dose, man.Sv</td>
<td>12,7·10^5</td>
<td>5,0·10^5</td>
<td>15,0·10^5</td>
</tr>
<tr>
<td>Collective effective dose equivalent resulted from thyroid irradiation, man.Sv</td>
<td>6,35·10^4</td>
<td>2,5·10^4</td>
<td>7,5·10^4</td>
</tr>
<tr>
<td>Mean individual dose of thyroid irradiation, rem</td>
<td>19,3</td>
<td>3,0</td>
<td>6,9</td>
</tr>
</tbody>
</table>

Date on collective doses given in Tables 1 and 2 were used in our assessment of stochastic effects of the Chernobyl accident in Belarus as well as for comparison in the Ukraine and Russia. By the evaluation of the numbers of solid cancers we used as a collective doses of the whole body irradiation the sum of collective equivalent doses given in Tables 1 and 2. Results of our assessment are presented in Tables 3 and 4. In our prognosis of deleted radiological effects we have used the data of the UNSCEAR 94 Report [7].

Table 3: Forecast of stochastic effects in Belarus, the Russian Federation, and the Ukraine as a result of the Chernobyl accident (DDREF = 1).

<table>
<thead>
<tr>
<th>Effect</th>
<th>Belarus</th>
<th>Russia</th>
<th>Ukraine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid cancer (morbidity)</td>
<td>20300</td>
<td>8000</td>
<td>24000</td>
</tr>
<tr>
<td>Thyroid cancer (mortality)</td>
<td>2030</td>
<td>800</td>
<td>2400</td>
</tr>
<tr>
<td>Leukemias (mortality)</td>
<td>1300</td>
<td>760</td>
<td>1550</td>
</tr>
<tr>
<td>Solid cancers other than thyroid cancer (mortality)</td>
<td>12700</td>
<td>7400</td>
<td>15100</td>
</tr>
<tr>
<td>All cancers and leukemia (mortality)</td>
<td>16030</td>
<td>8960</td>
<td>19050</td>
</tr>
</tbody>
</table>
Table 4: Forecast of stochastic effects in Belarus, the Russian Federation, and the Ukraine as a result of the Chernobyl accident (DDREF = 2).

<table>
<thead>
<tr>
<th>Effect</th>
<th>Belarus</th>
<th>Russia</th>
<th>Ukraine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid cancer (morbidity)</td>
<td>10150</td>
<td>4000</td>
<td>12000</td>
</tr>
<tr>
<td>Thyroid cancer (mortality)</td>
<td>1010</td>
<td>400</td>
<td>1200</td>
</tr>
<tr>
<td>Leukemias (mortality)</td>
<td>650</td>
<td>380</td>
<td>775</td>
</tr>
<tr>
<td>Solid cancers other than thyroid cancer (mortality)</td>
<td>6350</td>
<td>3700</td>
<td>7550</td>
</tr>
<tr>
<td>All cancers and leukemia (mortality)</td>
<td>8010</td>
<td>4480</td>
<td>9525</td>
</tr>
</tbody>
</table>

The data on morbidity and mortality from radiation-induced thyroid cancers were calculated on the basis of the risk coefficients [8].

According to our estimations the Chernobyl accident will cause about 20000 additional thyroid cancers (2000 fatal thyroid cancers) among children and adults of the affected areas of Belarus. About 10 per cent of this number can be fatal. We have estimated the number of radiation-induced thyroid cancers in Russia as 8000 (800 fatal thyroid cancers). For the Ukraine we prognosed 24000 additional thyroid cancers (2400 fatal thyroid cancers). Considering our method of collective thyroid dose assessment one can believe that these data on the number of additional thyroid cancers are upper limits of possible thyroid cancers.

The data discussed above have been estimated by use of the factor DDREF=1, which is recommended by the ICRP for the case of acute irradiation by high doses and dose rates [9]. For chronic irradiation of the population by low doses the ICRP recommends the value of the reduction factor DDREFF equal to 2. This factor has a very simple meaning. Practically it reflects the fact that in case of chronic irradiation the latency period is higher than by acute irradiation with the same dose. The permanent decreasing of the life expectancy in Belarus, the Ukraine and Russia can cause such situation that many radiation induced will not appear at whole. The factor DDREFF = 2 seems from these reasons more justified than DDREFF = 1. Table 4 presents data calculated with DDREFF = 2.

We have assessed the total number of radiation-induced fatal cancers and leukemias in Belarus, Russia and the Ukraine, as a result of the Chernobyl accident for the DDREFF factor equal 2 as about 22000 with about 8000 cases in Belarus, 4500 in Russia and 9500 in the Ukraine.

We understand that the results of our assessment have rather qualitative than quantitative character because of many limitations in our study. At the same time we believe that our data give quite accurate assessment of stochastic effects that can result due to the Chernobyl accident. As can be seen from data given in [5] in the time 1986 - 1997 about 3260 additional thyroid cancers manifested in Belarus or about 33% from prognosed with DDREFF equal to 2. The total number of thyroid cancers prognosed in [2] from the dynamic of the incidence of thyroid cancer incidence in Belarus in 11 years after the Chernobyl accident is 7000 cases. It is 70% of thyroid cancers that were forecasted in [6] with DDREFF = 2.

It is well known, that the reliable data on the increase of the morbidity on thyroid cancer among children of the affected areas of Belarus were established already at the end of the 80s [5,10]. However, at the end of 80s no such increase in the morbidity on thyroid cancer was established in Russia or in the Ukraine. The difference in the incidence in thyroid cancer can be explained very easy on the basis of the data in Table 2. They show that the highest mean individual thyroid doses were delivered by the Chernobyl accident to the residents of the affected areas of Belarus and the lowest to the Russian population. It is known that the latent periods of stochastic effects induced by the radiation depend from the irradiation doses. The lower the irradiation dose is, the longer is the latent period. This is an explanation why
marked increase in the thyroid cancer incidence was registered first in Belarus and then in the Ukraine and later in Russia.

Our data can also answer the question why there are no additional leukemias among the residents of the affected areas of Belarus, Russia and the Ukraine up to present time[10]. This contrasts the data established among the Hiroshima and Nagasaki inhabitants that survived the atomic bombardment. Additional cases of leukemia among them were registered firstly, and only then the radiation-induced solid cancer. We suggest the following explanation for these differences in the manifestation of stochastic effects among the irradiated populations of Belarus, Russia, the Ukraine and the residents of Hiroshima and Nagasaki.

The survivors of the atomic bombardment of these Japanese cities received much higher doses on bone marrow and thyroid than residents of the territories affected by the Chernobyl accident. In addition, the whole body doses and thyroid doses in the case of inhabitants of Hiroshima and Nagasaki were practically the same. On the contrary, thyroid doses among the affected populations of Belarus, Russia and the Ukraine are practically one order in magnitude higher than doses on the whole body (compare the data of Tables 1 and 2). This is according to our point view the reason of earlier manifestation of solid cancer (thyroid cancer) than leukemia in Belarus, Russia and the Ukraine.

REFERENCES
CONTAMINATION OF VEGETATION IN BELARUS BY TRANSURANIUM RADIONUCLIDES DUE TO CHERNOBYL NPP ACCIDENT

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ABSTRACTS. Contamination of some part of the Belarus area with radioactive fall-out due to Chernobyl NPP (ChNPP) accident is characterized by plutonium spots not only in 30-km zone but in areas adjacent to it.

The authors studied the levels of trasnuranic elements (TUE) accumulation in different plant species depending on soil contamination density and pH of soil solution. Specific activity of overground phytomass of wild and agricultural plants was shown to vary from 0.06 to 5.9 Bq/kg for $^{241}$Am and for $^{239,240}$Pu - from 0.03 to 2.9 Bq/kg. The problems on effect of different factors on TUE mobility in soil-plant system are discussed.

INTRODUCTION. The Chernobyl NPP accident in 1986 has resulted in additional contamination, besides global fall-out, of the Belarus area by the components of nuclear fuel with a high content of $^{239,240}$Pu. Contamination density owing to these elements reaches maximum value $1.1 \times 10^3$ Bq/m$^2$ gradually decreasing up to level of global fall-out to the north of Belarus. At present, as a result of beta - decay of $^{241}$Pu , the $^{241}$Am content in soil increases progressively and according to the prediction will be achieve maximum value in 2058 [1,2]. The possibility of plutonium and americium involvement in biological cycles seemed to be probable. Since the central link of trophic chains directly related to human health is plants , assessment of vegetation contamination levels in post-Chernobyl period is of priority character.

METHODS. In 1996-1998 investigations were carried out in natural vegetable complexes and agricultural crops in 30-km zone of ChNPP and the adjacent areas contaminated by plutonium and americium. Testing grounds were located in most typical meadow- and forest ecosystems of Gomel Region in the Republic of Belarus [4-5]. Objects under investigation under natural conditions were dominant species of woody plants, shrubs and herbs as well as mosses and ferns. TUE transfer from soil to agricultural crops was studied in field trials conducted in 30-km zone of ChNPP (v.Orevichi in Khoiniki District) and beyond its borders (v.Novoselki in Khoiniki District). Selection of soil and plant samples was performed according to [2,3]. Activity of $^{239}$Pu and $^{241}$Am was measured in soil and plant samples by the procedures [1,2]. X-radiation and low-energy $\gamma$-radiation spectrometer of the “Intertertechnique” firm and $\alpha$-spectrometer of the ORTEC firm, model 476A were used. The accuracy of measurement results was 20 -30 % depending on americium and plutonium content in the samples. TUE transfer coefficients from soil to plants were calculated as a ratio of a specific activity of plants (Bq/kg dry weight) to soil contamination density (Bq/m$^2$)

Contribution of extraroot (aerial) way of contaminating plant overground organs by TUE was determined by using A.Zabolotny's "bag" method [3].
EXPERIMENTAL. TUE accumulation in plants was revealed to take place predominantly during root nutrition because due to aerial contamination of the overground organs not above 3% of their total content penetrated there.

The result of the analyses have detected a wide range of TUE accumulation levels in wild plants: 0.03-2.9 Bq/kg for $^{239+240}$Pu and 0.06-5.9 Bq/kg for $^{241}$Am depending on location and TUE contamination density of testing grounds, species attribution and growth conditions for plants (see Table).

### Table

Description of $^{241}$Am and $^{239+240}$Pu accumulation in overground phytomass of wild and cultivated plant species and $^{241}$Am transfer coefficients (TC) in the soil-plant system under different edaphophytocenotic conditions of TUE-contaminated areas

<table>
<thead>
<tr>
<th>Plant species</th>
<th>TUE content in plants, Bq x kg$^{-1}$ dry weight</th>
<th>$^{241}$Am contribution to total TUE activity, %</th>
<th>$^{241}$Am transfer coefficients, m$^{2}$ x kg$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$^{239+240}$Pu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Testing ground 39 (8 km from CNPP):</td>
<td>Lichen pine forest.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH$_{KCl}$ in a layer of 0-10 cm deep = 4.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus silvestris (pine-needles)</td>
<td>1.70</td>
<td>0.53</td>
<td>76.2</td>
</tr>
<tr>
<td>Cytisus ruthenicus</td>
<td>2.50</td>
<td>0.71</td>
<td>77.9</td>
</tr>
<tr>
<td>Pteridium aquilinum</td>
<td>0.74</td>
<td>0.34</td>
<td>68.5</td>
</tr>
<tr>
<td>Calamagrostis epigeios</td>
<td>5.90</td>
<td>2.90</td>
<td>67.0</td>
</tr>
<tr>
<td>Testing ground 3 (45 km from CNPP):</td>
<td>Bilberry pine forest.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH$_{KCl}$ in a layer of 0-10 cm deep = 3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus silvestris (pine-needles)</td>
<td>0.50</td>
<td>0.45</td>
<td>52.6</td>
</tr>
<tr>
<td>Vaccinium myrtillus</td>
<td>1.31</td>
<td>0.37</td>
<td>78.0</td>
</tr>
<tr>
<td>Pteridium aquilinum</td>
<td>0.17</td>
<td>0.048</td>
<td>78.0</td>
</tr>
<tr>
<td>Calamagrostis epigeios</td>
<td>0.15</td>
<td>0.046</td>
<td>76.5</td>
</tr>
<tr>
<td>Testing ground 21 (160 km from CNPP):</td>
<td>Mossy pine forest.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH$_{KCl}$ in a layer of 0-10 cm deep = 4.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus silvestris (pine-needles)</td>
<td>0.30</td>
<td>0.70</td>
<td>30.0</td>
</tr>
<tr>
<td>Pleurozium schreberi</td>
<td>0.10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Testing ground 40 (16 km from CNPP):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottomland herb-cereal meadow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demo-humic gley soil.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_{\text{KCl}}$ in a layer of 0-10 cm deep = 5.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genista tinetoria</td>
<td>0.08</td>
<td>0.036</td>
<td>69.0</td>
</tr>
<tr>
<td>Calamagrostis epigeios</td>
<td>0.40</td>
<td>0.13</td>
<td>75.5</td>
</tr>
<tr>
<td>Molinia coerula</td>
<td>0.10</td>
<td>0.048</td>
<td>67.6</td>
</tr>
<tr>
<td>Carex acuta</td>
<td>0.40</td>
<td>0.10</td>
<td>80.0</td>
</tr>
<tr>
<td>Testing ground 11a (30 km from CNPP):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereal-herb-rush meadow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaty-humic gley soil.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_{\text{KCl}}$ in a layer of 0-10 cm deep = 3.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calamagrostis epigeios</td>
<td>0.61</td>
<td>0.19</td>
<td>76.3</td>
</tr>
<tr>
<td>Molinia coerula</td>
<td>0.16</td>
<td>0.07</td>
<td>69.6</td>
</tr>
<tr>
<td>Juncus conglomeritos</td>
<td>0.32</td>
<td>0.19</td>
<td>62.7</td>
</tr>
<tr>
<td>Betula pubescens (leaf)</td>
<td>0.06</td>
<td>0.034</td>
<td>63.8</td>
</tr>
<tr>
<td>Testing ground 86 (42 km from CNPP):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Former cultivated cereal meadow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ameliorated peaty-humic gley soil.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_{\text{KCl}}$ in a layer of 0-10 cm deep = 8.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agropyron repens</td>
<td>0.050</td>
<td>0.020</td>
<td>71.4</td>
</tr>
<tr>
<td>Cirsium arvense</td>
<td>0.43</td>
<td>0.12</td>
<td>78.2</td>
</tr>
<tr>
<td>Urtica dioica</td>
<td>0.99</td>
<td>0.12</td>
<td>89.2</td>
</tr>
<tr>
<td>Field trial «Orevichi» (27 km from CNPP):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivated demo-podzolic sandy soil.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_{\text{KCl}}$ in a layer of 0-20 cm deep = 5.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lupinus luteus</td>
<td>0.69</td>
<td>0.51</td>
<td>57.5</td>
</tr>
<tr>
<td>Cecale cereale</td>
<td>0.13</td>
<td>0.10</td>
<td>56.5</td>
</tr>
<tr>
<td>Triticale X</td>
<td>0.04</td>
<td>0.08</td>
<td>33.3</td>
</tr>
<tr>
<td>Bromus inermis</td>
<td>0.88</td>
<td>0.21</td>
<td>80.7</td>
</tr>
<tr>
<td>Lolium perenne</td>
<td>1.00</td>
<td>0.28</td>
<td>78.1</td>
</tr>
<tr>
<td>Melilotus albus</td>
<td>0.24</td>
<td>0.16</td>
<td>60.0</td>
</tr>
<tr>
<td>Trifolium pratense</td>
<td>0.87</td>
<td>0.58</td>
<td>60.0</td>
</tr>
<tr>
<td>Field trial «Novoselki» (50 km from CNPP):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivated demo-podzolic sandy loam soil.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_{\text{KCl}}$ in a layer of 0-20 cm deep = 5.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lupinus luteus</td>
<td>0.25</td>
<td>0.33</td>
<td>43.0</td>
</tr>
<tr>
<td>Avena sativa</td>
<td>0.15</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trifolium pratense</td>
<td>0.49</td>
<td>0.34</td>
<td>59.0</td>
</tr>
<tr>
<td>Dactylis glomerata</td>
<td>1.20</td>
<td>0.80</td>
<td>60.0</td>
</tr>
<tr>
<td>Lolium perenne</td>
<td>1.9</td>
<td>0.46</td>
<td>80.5</td>
</tr>
</tbody>
</table>

The content of $^{239,240}\text{Pu}$ and $^{241}\text{Am}$ in vegetation of forest phytocenoses decreased successively with an increase in the distance of testing ground from the ChNPP and a decrease in soil contamination density. Broom (Cytisus ruthenicus), bilberry (Vaccinium myrtillus) and needles of conifer (Pinus silvestris) were characterized by highest values. As
for the TUE accumulation levels is representatives of meadow flora, nettle (Urtica dioica), Cirsium arvense, sedge (Carex acuta) and rush (Juncus conglomeratus) can be distinguished. The content of $^{241}\text{Am}$ in phytomass was higher than that of in all species studied.

Transfer coefficients of $^{241}\text{Am}$ did not depend on soil contamination ($r = -0.596$). The most intensive $^{241}\text{Am}$ migration to plants ($1.6\times10^{-3} - 1.4\times10^{-2} \text{m}^2\times\text{kg}^{-1}$) was observed in bilberry pine forest on acid dermo-podzolic gleyic soil. However, a direct relation between biological $^{241}\text{Am}$ mobility and the soil acidity level was disturbed at the values of pH$_{\text{KCl}} > 6.0$. Thus, at pH$_{\text{KCl}} = 8.52$ the transfer coefficients of $^{241}\text{Am}$ to plants of the former cultivated meadow exceeded the values at order meadow testing grounds by an order or by a factor of $10^2$ (see Table, Testing ground 86) that, probably, can be accounted for by variation in americium acidity level and an increase in its mobility in alkaline pH range.

A high biological mobility level of $^{241}\text{Am}$ in the area adjacent to 30-km zone of ChNPP (v. Novoselki) where americium transfer coefficients to cultivated plants were higher by a factor of 5-15 than inside the zone (v. Orevichi) attracts attention in the experiments with agricultural plants. This can be caused by differences in the degree of dispersion and the physicochemical state of fuel particles [1]. Perennial grasses ($1.6-6.1\times10^{-3} \text{m}^2\times\text{kg}^{-1}$) and yellow lupine ($8.1\times10^{-3} \text{m}^2\times\text{kg}^{-1}$) were characterised by high transfer coefficients.

**CONCLUSION**

So, the results of investigations demonstrate a real threat of $^{241}\text{Am}$ and $^{239+240}\text{Pu}$ involvement in trophic chains via wild plants as well as their penetration in foodstuffs when conducting agricultural work in the areas adjacent to 30-km zone. This points to the necessity for monitoring of TUE dynamics in natural ecosystems and development of method for exogenous exposure limiting their transfer to food cultivated plants.

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RISK OF FOOD CONSUMPTION IN THE AREAS CONTAMINATED BY THE CHERNOBYL ACCIDENT

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ABSTRACT
The most actual problem both for people who live in the contaminated areas and for the whole population of the Republic of Belarus is the consumption of contaminated foodstuffs. This problem carries the global character due to the serious agricultural crisis and the lack of many products such as eggs, cheese and other milk products even in the capital without saying of the region and centers.

The failure of the economic policy makes the current political regime look for the extraordinary means to gain the population support. Thus, for example, there is a special program for the nearest years which concerns the rehabilitation of the Kostiukovitchi district of the region of Moguilev with the level of radiation from 5 to 15 Ci. That is these areas are considered by the central and local authorities to be safe for living and for agricultural works. They encourage also people to be back and to work here.

In fact, after the wide scale relocation at the first post-catastrophe years and at the beginning of 1990 many people are still living in the proximity of the contaminated areas and working at the State farms or keeping the personal plot. The State farms are producing the stock-breeding and plant-growing products in the contaminated areas which is spread throughout Belarus and even exported in the Ukraine and in Russia. The officials assert that these agricultural products are safe because of the severe control based on the scientifically and medically grounded norms.

Nowadays Cs-137 and Sr-90 are the main radioactive elements, which effect the situation in Belarus. For the 01.01. 1996 according to the statistics 1351,2 thousand hectares of lands contaminated by Cs-137 with the density more than 1 Ci / km2 were used for the agricultural production in Belarus. Agricultural lands with the density 1*5 Ci/ km2 occupied 993,7 thousand ha, 5*15 Ci/km2*354,1 thousand ha, 15*40 Ci/km2 * 61,5 thousand ha. Among them 55,1 thousand ha were contaminated with Sr-90 with the density more than 0,15 Ci/km2. The most contaminated agricultural lands are in the Gomel (58%) and Moguilev (27%) regions.

During our visit to the Kostiukovitchi foodstuff control station there was revealed that the products were tested for Cs-137 only. But it is well known, that after a while Cs-137 becomes less accessible to the plants than Sr-90. As to Sr-90 it is easily dissolved in water and therefore it is absorbed by plants. According to the data analysis of the Ministry of Agriculture and Food of Belarus the coefficient of Cs-137 transition in main agricultural plants reduced as much as 1,5 times and up to 4 times as compared with 1987. It is contrarily...
for Sr-90, which has a tendency towards the increase. There was no apparatus for testing Sr-90 in the district in virtue of its high price. For example, the established accessible norms for milk are 111 Bq/kg, meat products (beef, mutton) -- 600 Bq/kg and so on. For some products (spices, honey) the consumption of which is less than 10 kg. per year the accessible levels are 10 times high than for other products.

Last time people from the contaminated areas display the particular tendency, which may be considered as the protective reaction, that is people consciously ignore any information about the radioactive contamination of their territory. Under the current economic depression people try not to make attention to the radiation factor. But the information about the levels of radiation, the most contaminated places, rules of the safe living and modes of personal protection is extremely useful. According to our surveys only 31.8% of the public were interested in such information and 8.9% were not interested at all.

Only 10% of the public found normal the conditions of life in the contaminated areas, 32.9% considered that they had to take care of them and 27.4% found them rather dangerous for the life. At the same time 26.3% of the public were not able how to reduce the risk of radiation. 30.4% were sure that the risk should be reduced if they moved away. 14.3% stressed that the risk might be less if you ate clean foodstuff. In practice only 6.2% of the public thought that they had an opportunity to eat ecologically clean and healthy products. 79.7% of the persons stressed, that they did not have such an opportunity. 46.7% were not able even to call the ecologically clean products. Nevertheless, the situation with the population health is extremely sinister. There is an increase of new-born children with different pathologies. About 10% of children suffer from chronic diseases. At the same time one may see the increase of the death-rate which was about 13% in 1996. That year the number of patients with nervous and stomach diseases increased by 5%, with psychic and endocrine system diseases including the thyroid gland increased by 6%, with malign tumors* by 23%.

The majority of the population in the clean regions and in the capital ignore what kind of products they consume. But people in the restricted areas work consciously their personal gardens with the radioactive ashes and dung as the fertilizers by ignorance. People in the contaminated areas are careless and indifferent to their health. But the problem is how to keep their children health. It should be said that despite very plausible economic situation the Belarus State tries to find additional means for the protection of children's health. Thus, there was organized the gratis nutrition in all the State children institutions from nurseries to the secondary school in the contaminated areas. Clean foodstuff products are supplied by special stocks. They are checked up by the medical services at these institutions. But children consume dirty foodstuffs in their families mainly from their home garden. People's salary in small towns is so poor that many of them do not afford themselves to buy children fruits and vegetables. In summer they go to the nearest forests to pick up berries and mushrooms, to fish in the local rivers. And though they assert they are familiar with the radioactive areas, nobody may say how clean are their forest provision and fish.

The sociological studies in the contaminated areas show that the explanation work how to reduce the risk of penetration of the radio-nuclides with the food into the human body is not effective. 65% of public interrogated in 1998 reported that they ignored how to reduce the concentration of the harmful substances in the products and 31% knew something. 73% of public in the restricted areas did not use any means to reduce the risk of growing of the
radioactive agricultural products. 79.3% of respondents were not sure to consume the clean products and 83.7% stressed the impossibility of their control.

The problem of the personal knowledge how to reduce the risk of living in the contaminated areas is rather acute. Thirteen years after the Chernobyl accident the population is passive towards any recommendations. There are many reasons for it. We had the following answers from the public of the extremely contaminated Dobruz and Vetka districts of the Gomel region to the question "Do you use any means for the reduction of radiation in the foodstuffs?". 2.7% of the public do it regularly, 19.7%-- do it sometimes, 73%-- never do it, and only 0.3% of the public are sure that there is no radiation. So many negative responses belong to the aged public, who did not leave the contaminated areas and became quite indifferent to their health. They prefer rather to live the rest of the life in the country, than to move to another place. People did not prevent themselves because they have no opportunity to check up rapidly and inexpensively the quality of products they grow in their garden or pick up in the forests. People do not have dosimeters and the stations for the radiation controls of food are in the district centers rather remote from villages. The local residents usually do not want to spend their free time to go there. We think, that these centers should be equipped at the local schools and teachers and schoolchildren should be taught to test the radiation. Any child could bring at school the suspicious product and test it for the radiation. It is evident, that new attitudes towards the responsibility for the own life and health should be formed among schoolchildren and teachers. It is difficult to change the middle aged people's behavior and psychological stereotypes of living in the contaminated areas. Children must know the rules of personal behavior in the contaminated areas. Special TV programs, books about radiation and its consequences with color illustrations, computers' games and practical lessons at schools should be very useful for children. People in the contaminated areas must know the simplest rules of individual protection.

It is necessary to wash carefully any vegetable and fruit even potatoes. When salting vegetable and fruit should be washed twice. Never put ashes and animal dung as a fertilizer. Any vegetables and fruit from the garden should be tested for the radiation. Any berries, mushrooms and wild fruit from the forest must be tested. Even keeping these recommendations one may protect the health.

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2. Social Support an Social and Psychological Rehabilitation of People suffered from the Chernobyl Accident. Report, based on the Sociological Data, carried out in 1998 by the Institute of Sociology of the National Academy of Sciences of Belarus.
Between 1949 and 1957 Mayak Nuclear Facility located in the Chelyabinsk region released some discharges of radiochemical production wastes into the Techa River and Lake Karachay which resulted in an extensive contamination of large territories with long lived radionuclides such as 90 Sr, 137Cs, 239 Pu. Between 1994 and 1996 the research team of Siberian Medical University conducted the chromosome analysis and the electron-spin resonance (ESR) spectrometry of tooth enamel in the radiation exposed inhabitants of four settlements in the Techa River region. We observed significantly increased levels of chromosome aberrations in the radiation-exposed inhabitants as compared to the controls. The ESR signal intensity and the chromosome aberration frequency in lymphocytes of the tooth donors showed a good correlation. Moreover, there were a good correlation between the level of whole body 137 Cs activity detected by a whole body radiation counter and the frequency of chromosome aberrations among the radiation exposed inhabitants. The data showed that 15% of the inhabitants of the Muslyumovo settlement received a radiation dose exceeding 100 cGy. The frequency of chromosome abnormalities reached its peak in the persons born between 1949 and 1957. We suppose that radionuclides incorporated in the body are responsible for the chromosome aberrations in the inhabitants.
RISK ASSESSMENTS OF FATAL CANCER ASSOCIATED WITH PROTRACTED EXPOSURE OF POPULATION OF BELARUS AFTER THE CHERNOBYL ACCIDENT

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Annual effective doses (AED) for adult population of Belarus regions contaminated by Chernobyl radioactive fallout have been computed for period 1986 – 2050 on basis of empirical and prognostic data on radionuclides activity concentration in foodstuffs. The obtained AED values were used to evaluate the lifetime probability of leukemia and fatal cancer by applying the approach described by J. B. Robb and C. R. Muirhead (J. Radiol. Prot., 1994, v. 14, No 1, pp. 25 – 34).

Figures A and B show computed the lifetime probability $R$ of fatal cancer for female population (20 years old) of settlements placed in eastern (A) and southern (B) regions characterized by different factors of $^{137}$Cs transfer from soil to agricultural products.

The presented results have been obtained for areas with mean level of $^{137}$Cs deposition on soil $S=185$ kBq/m$^2$. For comparison, risk assessments for case when AED=1 mSv are shown by dashed lines.

An application of derived fatal cancer risk time-dependences for optimization of protective measures in different regions of Belarus is analyzed.
MODELING OF MEDICAL RISKS OF TECHNOGENIC RADIATION CATASTROPHIES (Post-Chernobyl Investigations).

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ABSTRACT.
Chernobyl NPP accident was considered as a model of radio-ecological human health risks estimation. “Chernobyl” case of radio-ecological situation appeared as an acute “shock” (predominantly I-131 & I-133) on the background of long-term low dose irradiation with the complex of radionuclids. Such type of irradiation in childhood caused occurrence of the specific pathological process of metabolic disorders which led to dystrophic & sclerotic changes in organs and systems, put in other words - to cancerogenesis.

The children cases of DRD-syndrome (of disadaptational regulative disorders in all systems depend on deregulation of circulatory system) or the specific form of permanent hypersympathicotonia is the marker of the radio-genetic pathology initiation. The base model of its development was processed as the function of time in the form of “going out periodic fluctuations”. Each fluctuation is one stage of the process: the 1-st - DRD-syndrome, the 2-nd - functional somatic pathology, the 3-rd - organic pathology.

But the last observations proved that the base model has to be modified as the “auto-oscillational” one - due to the episodically actions of “radio-iodine outcomes” out of the destroyed reactor.

DEREGULATION INFLUENCE OF “RADIO-IODINE SHOCK” ON CHILDREN ORGANISM.
Chernobyl NPP accident should be considered as the model of radio-ecological human health risks estimation. Chernobyl case of radio-ecological situation appeared as the acute «shock» (predominantly radio-iodine I-131 & I-133) on the background of long-term low dose irradiation with the complex of radionuclids.

12 years observations of the suffered children had proved the influence of «Chornobyl type» emission. During a long-time prospective clinical and epidemiological investigations the mathematical model was created that gave the possibility to proclaim the «iodine shock» as one of the most active pathogenie factor in Ukrainian children psychosomatic pathology after Chernobyl NPP accident. Deregulation of circulatory system and the hypo-oxygen status in organs and tissues, low level of the ionizing calcium (Ca$^{2+}$) and IgA, ultrasound Doppler phenomenon of the IVRT prolongation have taken the first place in the after-Chernobyl pathogenesis.

It was proved that there is an association between the prevalence and incidence of the specific form of permanent hypersympathicotonia, e.g. prevalent sympathetic form of autonomic nervous system disorders (ANS disorders) and radio-iodine thyroid dose in children irradiated in the 1-st and the 2-nd generation (born from irradiated parents). Risk Ratio ANS disorders among irradiated with thyroid dose 53-250 eGy was: 7.15 for Kyiv children 0-7 years of age, who stayed in Kyiv during April-may 1986; 7.30 for children evacuated from Pripiat town to Kyiv after Chernobyl NPP accident; 7.99 - for directly and in the 2-nd generation irradiated
with radio-iodine children dwelling in radio-contaminated territories (in the West and the East traces of radio-contamination). In the first 5 years after the accident, ANS disorders were found in 80% inspected children, irradiated with more than 50 cGy thyroid and 1.2-30 mZv whole body doses.

The rate of ANS disorders increasing among the 1-st generation of children directly irradiated by «iodine shock» approximated:

\[ y = 1/a + b \cdot e^{-x} \]; where \( x \) - differential of time passed after the accident;
\[ a, b \] - specific to the Chornobyl accident situation coefficients.

The hypothesis of radio-iodine etiology of deregulation disorders in the 1-st irradiated generation was confirmed by regression analysis. There was high correlation between the frequency of ANS disorders and diseases of digest system (erosive gastroduodenitis, holecisto-holangitis, intestinal disbacteriosis, Helicobacter Pylory infection of stomach) - \( r = 0.92 \); hyperplasia of thyroid gland - \( r = 0.98 \); psychic disorders (astheno-neurotic and minor depressive states) - \( r = 0.8 \). Psychosomatic gastropathology can be find in 25% irradiated children.

LONG-TERM NON-STOCHASTIC EFFECT OF «CHORNOBYL TYPE» EXPOSITION IN CHILDHOOD.

Then it was found that in children cohort irradiated with thyroid dose approximately 200 Gy ANS disorders in 25% incidents were complicated with the specific syndrome of combined disadapational regulative disorders in all systems dependent on deregulation of circulatory system (DRD-syndrome - in 1-5 years after the accident). DRD-syndrome was marked by severe permanent headache, by disautonomia with prevalent sympathicotonia, by increasing of LDH level in lymphocytes of the peripheral blood, by decreasing of cardiac index (CI) lowely 2.8 L/min/m, by increasing of interval QT on electrocardiogram to 10% and more from individual norm, by decreasing of the Ca blood level lowely 2.28 mmol/L, by increasing of the immunoglobuline A blood level, by increasing (in dependence of thyroid gland dose) of curvature of the somato-sensory short latency evoked potentials EBW, N13, N9 at the end of n.medianus stimulation and by the absence of wave N20 fade. In children cohort irradiated with thyroid dose 1000 Gy and over ANS disorders where complicated with DRD-syndrome in 100% incidents. So, the most common non-stochastic effect of «Chornobyl type» exposition displays itself as DRD-syndrome.

Further observations have revealed the strengthening of functional pathology in organs and systems of the exposed children injured with DRD-syndrome. In 6-8 years after the accident it arose the functional cardiopathies, displasies of haemopoiesis, secondary disorders of immunity, nephritis, erosive hypo-plastically gastritis. This pathology quickly develops in case of non-adequate treatment. The origin of secondary injures of immunity accompanied by the activation of auto-immunologic reactions stimulated by DRD-syndrome promotes the radiogenetic cancerogenesis (7-10 years after the accident and farther). Chronic functional diseases had risen due to DRD-syndrome would develop in serious organic illness. In the case of non-adequate treatment in 15-20 years after the accident the intensification of dystrophic and formation of sclerotic changes in organs and systems (e.g. cardiofibrosis, nefrosclerosis, pneumosclerosis) would be expected for all alive persons who had DRD-syndrome in their childhood. The minimum amount of such patients in the former USSR may be estimated by the figure of 50000 (in Ukraine - of more than 20000).
So, the main medical risk of "Chornobyl type" irradiation in childhood is the occurrence of specific pathological process of metabolic disorders which led on one hand - to dystrophic & sclerotic changes in organs and systems, on the other hand - to cancerogenesis. The increasing incidence of DRD-syndrome in children population is the marker of the radio-genetic pathology initiation. And the incidence rate of DRD-syndrome in 5-6 years after the accident should show the maximum quantity of serious organic illness due to Chornobyl NPP accident.

The principal model of radio-genetic pathological process based on DRD-syndrome development in irradiated children population was reflected graphically as the function of time as "going out periodic fluctuations". Each fluctuation is one stage of the process: the 1-st - DRD-syndrome prevalence in irradiated cohort, the 2-nd - functional somatic pathology prevalence, the 3-rd - serious organic pathology prevalence (fig. 1). Analytically this dependence can be presented as the system of non-linear (polinomic) equations. It needs additional investigations to accurately parameterize this model.

![Graph of pathological process](image)

**Fig. 1.** The base model of radio-genetic pathological process started by Chornobyl type irradiation of children's population evacuated from Pripiat to Kyiv town in 1986 [A.Y. Lagutin, O.G. Rogozin].

Last observations revealed unexpected returns of DRD-syndrome among irradiated persons and even its eruption among children born by irradiated parents dwelling in Kyiv now. This outbursts can be associated with accidental «radio-iodine outcomes» out of the destroyed IV
reactor of Chornobyl NPS in 1992 (October), 1996 (April) and 1998 (May - June). So the principal model of «going out periodic fluctuations» of after Chornobyl DRD-syndrome can be modified into «auto-oscillation» one to take into account the periodical radio-iodine «aftershocks» influence.

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The analysis of the mental morbidity in the population residing in the territories affected after the accident has been carried out. During the last 10 years the number of mental disorders of non-epileptic focal pattern (epilepsy, depressive disorders, anxiety, phobia) has increased by 20%. The prevalence of depressive states increased to 2.5 times.

The purpose of this paper is to discuss the mental health of the population in the territories affected by the accident. Studies conducted with the National Health Committee in the population of the territories indicated that the level of mental disorders has diminished during the last 3 years. At the same time, the prevalence of mental disorders in the population has slightly increased to 1.5 times.

The analysis revealed that the most common mental disorders in the population are the utilization of substances, anxiety, and depression. In comparison to that of the population not only amongst children, but also in the adult population, there has been a significant increase.

The analysis pointed out that mental disorders are lowering in the population of the territories affected. Mental disorders in the group of population suffering from the accident are not only more common, but also more severe than in the general population.
TRACK 5

SESSION 6

MENTAL RISK
The analysis of the mental morbidity in the population residing in the territories affected after the accident has been carried out. During the last 10 years the number of the mental diseases of non-psychotic level (neurosis, behavior disturbances, depression, anxiety, phobia) has increased by 20%. The parameter “first time reported sickness” has increased in 2,5 times. The increase of this parameter was detected in 1993. During the following years 1994-1998 both such parameters as morbidity and “first time reported sickness” tended to stabilize. Surveys conducted with the General Health Questionnaire in the population of the contaminated territories revealed that the level of mental disadaptation has diminished during the last 4 years. At the same time people residing in these areas began to evaluate health risks differently. Non radiation risks (social, economical, personal) are considered as high as the radiation ones.

Mental disturbances are met 5 times more often among the liquidators of the accident than among the rest of the population. However, starting with 1993 the parameter “first time reported sickness” has decrease by 25%. Surveys conducted with the General Health Questionnaire - 28 in the group of liquidators revealed the mental disturbances in 84-87 % of people. In comparison to that in the population, not only neurosis, behavior disturbances, anxiety but also organic disorders have been detected.

The analysis proved that risk of mental disturbance is lowering in the population of the contaminated areas whereas remains high in the group of liquidators even 13 years after the accident. Probably mental disturbances in those 2 groups are guided by the different pathogenetic mechanisms of the development.
STRESS-RELATED HEALTH-RISK AND MASS EXPOSURE TO TOXICOLOGICAL SUBSTANCE

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ABSTRACT
Exposure to toxic substances in the environment is an ever more common event, that may cause physical as well as psychological harm. The term “toxicological disaster” is used to designate instances of sudden, unexpected and large-scale exposure of to toxic substances. The mere threat of such an event may be a source of stress, associated with changes in mental health and changes in health-related behaviours. This literature review examines the health-risks related to the stressful experience of toxicological disasters. The paper gives an overview of the main characteristics of this experience and describes the stress-related health effects which have been profound effects on subjective health, especially on symptom reporting, and on a number of psychophysiological parameters. The evidence for a substantial impact of disaster-related stress on either physical or psychiatric morbidity in a clinical sense remains inconclusive. In this respect toxicological disasters may have a more pronounced effect on health-related behaviours, especially on reproductive behaviour (number of birth and abortions) and help-seeking-perception play an important role in the development of these health effects. The implications of these findings for risk-management and risk-communication in the aftermath of toxicological accidents are discussed.

INTRODUCTION
Over the past decades the scientific community has been confronted increasingly with health risk and socioeconomical risk related to exposure of the population to toxic chemical substances or physical agents such as ionizing and non-ionizing radiation. The source of these exposures varies dumping of waste products into the environment to accidents and illegal or accidental contamination of food products. It includes warfare (as in the Gulf war), industrial accidents (Chernobyl, Bhopal, Seveso), occupational exposure (asbestos, radar) and contamination of food (dioxin contamination of poultry in Belgium; toxic oil syndrome in Spain). Whereas risk analysis previously focussed it’s attention primarily on the potential physical consequences of such events (e.g. Grisham, 1986; Logue et al., 1981), more recent experiences are making it increasingly clear that, in addition, psychological mechanism are crucial mediators of these risks. There is a growing number of cases in which the psychological consequences overshadowed the direct physical effects, for example the Three Miles Island nuclear incident (Baum et al., 1983; Cormie & Howell, 1988) and the El Al the aeroplane crash in 1992 in Amsterdam (Inspectorate of Health Care, 1998). We will use the term “toxicological disaster” to designate instances of relatively sudden, unexpected and large-scale exposure to toxic substances, regardless of whether there is proof of an actual exposure that could incur a realistic threat to health.
In the aftermath of toxicological disasters, three groups of illness determinants play a role: the biological effects of the exposure itself, the stressful experience of the population and the response measures (Bertazzi, 1989). This review deals with the health effects which are determined by the stressful experience of the exposure itself, the perceived threat of such an exposure, or by the ensuing response measures, such as evacuation. These health effects may manifest themselves directly as changes in the mental or physical health status of the population, or more indirectly through changes in health-related behaviours. Outcome variables from each of these domains are taken into consideration and risk factors are described.

**STRESS-FACTORS RELATED TO TOXICOLOGICAL DISASTERS,**
Bertazzi (1989), in a review of industrial disasters and epidemiology, identified the following five major elements of the stressful experience, which determine the stress response following a toxicological disaster:

1) **Uncertainty.** It usually takes a while before the contaminant is identified and exact information concerning levels and risks are made public. As long as people are not aware of the exposure, no stress response occurs. Once people are notified, however, uncertainty about the possible health effects caused by the exposure to a toxic substance evokes a massive reaction in the population. An important contributing factor to the uncertainty is the lack of undisputed knowledge about the effects of the exposure. During the initial period after the event researchers and practitioners in the field often lack adequate technology and/or know-how to assess the physical and psychological consequences. This tends to be particularly, but not exclusively, the case in second and third world countries. In the long run this uncertainty often remains, because of the low bio-degradability of many toxic substances, e.g. radionuclides or dioxins, and the long period of latency of some of the health effects, which may become manifest only in future generations. Because of this protracted nature of the threat, toxicological disasters have been called 'diluted disasters' (Bertazzi, 1989).

2) **Housing and job insecurity.** Evacuation from the contaminated site and fear of contamination of homes and premises are important sources of stress. Loss of value of property may be an additional stress-factor. Other important indirect effects may be the loss of value of products from "contaminated" area's and a decline in tourism and other economical activities. These large scale social-psychological phenomena produce secondary stressors by causing economical problems for the exposed population (Petterson, 1988; Havenaar et al., 1996).

3) **Social rejection.** The victims of toxicological disasters may suffer from discrimination, as though they were carriers of some mysterious and noxious contaminant. Social rejection and discrimination of evacuees and inhabitants from contaminated regions has been reported following many toxicological events (Lifton, 1967; Fowlkes & Miller, 1992).

4) **Public debate and media siege.** In the aftermath of toxicological disasters, more often than not, heated public debates arise about the nature and extent of the health risk. The media play an important role, not only in transmitting the news about a toxicological event, but also in shaping the issues of the debate and in determining public perception of the events (Mazur, 1981).

**STRESS-MEDIATED HEALTH OUTCOMES OF TOXICOLOGICAL DISASTERS**
Rubonis & Bickman (1991), in a meta-analytic review about the mental health outcomes of and natural and man-made disasters, found no evidence for a differential effect of toxicological or other man-made disasters. The strongest predictor of psychopathology
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appeared to be a high immediate death toll. Below the health effects of toxicological disasters as described in the literature are summarized:

**Effects on physical health.** Several physiological manifestations of the stress response have been described, e.g., changes in blood pressure, catecholamine excretion in urine and changes in immune competence (Davidson & Baum, 1992; McKinnon et al., 1989; Bowles & Baum, 1989; Zaicev et al., 1992). The clinical significance of these changes is however uncertain. Subjective changes in physical health are a constant finding in the wake of toxicological disasters, e.g., more physical symptoms on self-report questionnaires, such as the SCL-90 (Bromet, 1989; Davidson & Baum, 1992; Prince-Embury & Rooney, 1988), or a subjective deterioration of health after exposure (Smith et al., 1986). The somatic complaints that are reported are usually rather unspecific, such as fatigue and headache.

**Mental health outcomes.** Increased levels of psychological distress and diminished performance on cognitive tasks are a common finding. Elevated rates of the symptoms of depression, posttraumatic stress and other anxiety disorders in exposed subjects have been found by many authors using both self-report questionnaires as clinical interview methods. Hypochondriasis and other forms of somatization are also often reported adverse outcomes. An increase in the prevalence of clinically significant disorders, however, has only been observed among specific risk groups, especially among mothers with young children (Bromet & Schulberg, 1986; Havenaar et al., 1995). The course of clinical psychopathology following disaster, if at all present, is probably relatively brief and self-limiting in most individuals. The increased prevalence and incidence found by Bromet & Schulberg (1986) and Smith et al. (1986) could be demonstrated up to 12 months after the event; after that, rates dropped to the usual levels. For psychological distress, subclinical pathology and psychological impairment a far longer persistence of symptoms has been reported, even as long as six years after the TMI incident (Davidson & Baum, 1992).

**Changes in health-related behaviours.** Several authors reported changes in health-related behaviour, including illness behaviour following toxicological disaster. Many studies have reported changes in reproductive behaviours. This may include both a reduction in the number of pregnancies and increased rates of induced abortions (Rachmatulin et al., 1992; Bertollini et al., 1990; Ericson & Källén, 1994; Irgens et al., 1991; Knudson, 1991).

A number of papers describe the effects of toxicological disasters on other health-related behaviours. Mileti et al. (1984) reported a clear rise in alcohol sales after the TMI crisis, which lasted for several days. Only minor changes were observed in the number of committed crimes, traffic accidents, suicides and psychiatric admissions, all falling within the range of normal fluctuations. Rachmatulin et al. (1992) reported an increase in sick-leave in factory workers near Chernobyl in the years following this accident, mostly related to psychological and psychosomatic problems. Lebedev (1992) found that in the first year following the Chernobyl disaster help seeking for psychological and psychiatric problems decreased. A similar finding has also been reported after natural disasters (Yates et al., 1989). Giel (1991) has described how the Chernobyl disaster changed medical survey-utilization in the affected republics and lead to an apparent, but probably spurious increase in all kinds of illnesses, such as dizziness, headache and hypertension.

**Risk factors**

Women with pre-school children appear to be especially at risk. This is probably related to the threat toxicological disasters carry for themselves and their young children (Bromet & Schulberg, 1986; Havenaar et al., 1995). Children themselves also appear to be at risk, and may show a wide range of internalizing and externalizing symptoms ranging from anxiety and depression to behavioural and school problems (Breton et al., 1993; Bromet et al., 1984; Sorenson et al., 1987). People who have been evacuated from disaster areas are also more at
risk (Havenaar et al., 1995). Unexpectedly, pre-existing psychopathology was not found to be associated with and increased vulnerability across studies (Bromet et al., 1989). Personality factors, such as locus of control, may act as modifiers in relation to outcome, as may be trust in the information, experts and authorities, religious beliefs, social support and (Davidson, Baum & Collins, 1982; Prince-Embry & Rooney, 1995; Goldstein et al., 1989; Sorenson et al., 1987).

DISCUSSION
A growing literature about the role of stress in health outcomes in toxicological disasters has emerged, especially during the past ten years. It should be noted, that the disasters which have been studied best so far have been relatively small in scale in comparison to major toxicological disasters such as 'Bhopal' or 'Chernobyl', a majority of which appears to take place in second and third world countries (Baum, 1987; Lechat, 1990; Bromet & Dew, 1995). In these countries the necessary experience and infrastructure to conduct epidemiological surveys is often lacking. Therefore, the findings of the studies reviewed above cannot be generalized to different cultural settings too readily, although some universality appears to be present in the outcomes of nuclear incidents in countries as remote as Japan, the United States, Brazil and the former Soviet Union.

Elevated levels of distress, as measured through self-report symptom questionnaires and changes in biological markers such as heart rate, blood pressure, catecholamine metabolism and immune parameters have been observed in exposed populations consistently. Anxiety symptoms, including those of posttraumatic stress, are reported most often. Somatic symptoms are also reported consistently. The source of these symptoms may be a mixture of be the physical effects of the toxic substance itself, the physiological manifestation of anxiety and depression and an increased awareness of physical symptoms or even outright hypochondriasis. The clinician and the epidemiologist who has to discern between these different sources of symptomatology may face a near impossible task.

In most cases, however, the increased symptom levels related to the stressful experience and its consequences reach the level of clinical significance. In this respect the studies on toxicological disasters are consistent with the literature on the psychological impact of disaster (Rubonis & Bickman, 1991) and on stress and health in general (Watson & Pennebaker, 1989). Apparently, the stress accompanying toxicological disasters leads mainly to subclinical changes. It has been hypothesized that increased symptom-reporting should be interpreted as a form of illness behaviour. This interpretation generates interesting testable hypotheses, which may also be relevant to the study of a number of related conditions, such as 'multiple chemical sensitivity syndrome' and 'sick building syndrome', in which unexplained non-specific symptoms arise after presumed exposure to low doses of toxic substances (Terr, 1994).

REFERENCES: a list of references is available on request from the first author

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ABSTRACT
Urban populations who have already experienced a disaster, danger is a real event that can happen any time. Risk perception in those cases benefits from the preceding experience of the catastrophe. Our research investigates the risk perception process, the stress reactions and the coping strategies in Mexican populations who experienced an industrial accident in 1984 and a big earthquake in 1985. These populations are exposed to another occurrence of this kind of disasters. Risk perception is a subject explored through different scientific approaches. Differences in the way of perceiving a risk have demonstrated that individuals do not have the same preferences in fearing dangers. Our research investigates the process of risk perception. We think that risk perception is a cognitive process evaluation of environmental dangers. We try to describe a theoretical model of psychological risk perception. We think that our perceptions are constructed from a stock of individual and social knowledge we get in our own life. So, an evaluation process that considers our individual specificity and our social values is able to evaluate dangers. We got some interesting results showing many differences in perceiving and managing risks in our two populations.

INTRODUCTION
Facing to environmental factors the perception of risks and dangers can produce stress reactions if it is interpreted like a threat. Richard Lazarus upholds the interaction stress concept and developed a theory about the dialectic link between individuals and their environment. This concept implies that a stimuli produces stress only when this stimulation is appraised like overflowing individual resources and so menacing the psychological well-being. Psychological evaluation (Lazarus and Monat 1985) of stressors give a response to cope danger. Different behaviours to cope a stressful event were defined by Lazarus and Launier in 1978 as coping strategies. This term defines the whole process that protects individuals against aggressive events threatening their psychological stability.

RISK PERCEPTION PROCESS AND STRESS
Risk perception, according to us, is a cognitive and emotional assessment of the dangerous object that will determinate the personal approach to risk. According to Lazarus and Folkman's theories (1988) of cognitive evaluation of stress, there are two different moments: primary evaluation and secondary evaluation. If we considerate risk as a potential stress agent we will be able to describe two phases of risk assessment process. According to observations in our research we found some possible factors making part of this process:

Primary evaluation: We are talking about the nature of risk identification (flood, major accident, fire...) and the subjective probability of events manifestation (is it a voluntary risk or involuntary, does it have a high probability level? does it affect people directly or not?)
**Secondary evaluation**: This evaluation has four different modalities: external-internal control, insecurity feeling, external confidence degree and priority risk. The **external - internal control** pushes individuals to prevent threat or obtain benefits according to their own capacities (internal control) or the external circumstances (external control); **insecurity feeling** interacts with past experiences that helps to develop a security or insecurity feeling to face the event; the **external confidence degree** is related to the security feeling provoked by the public administrations which are responsible for watching over the city's safety or the personal confidence in abstract and supernatural forces; **priority risk** is a hierarchy of all preoccupations and dangers of individual's environment.

So we think that risk perception evaluation will interacts with stress and coping to face the risk situation. Evaluations will not be the same in both cases. We will define our hypothesis in the next paragraph.

**HYPOTHESIS**

In our first hypothesis we suppose that people exposed to an industrial accident risk will develop a higher level of stress than people exposed to earthquake risk. We think that physical presence of industries can be sources of a higher level of stress.

We expected to find differences in choices of strategies to cope risk between our two populations. If industries are in every day life watched and felt (odours) they can stimulate passive reactions because of the personal impossibility to get them out. In contrast people who experienced the earthquake do not have the same daily physic perception of the natural risk, so they probably have a more active coping than the other population. We suppose that stress reactions and coping reactions variability is not only the direct result of the nature of risk that individuals are exposed. We think that there is a variation of stress level and coping strategies choices in function of risk perception.

**METHODOLOGY:**

In our research individuals have answered three different questionnaires: a coping scale adapted from the ‘Echelle Toulouse de Coping’ (P. Tap, S. Esparbes, F. Sordes Ader in P. Tap, 1992), a perception risk questionnaire adapted from the Institute for Protection and Nuclear Safety (IPSN) request, and the psychological Stress Scale of Toulouse. Our questionnaires were submitted to 206 persons between 20 years old and more separated in two groups:

**Population 1**: Industrial accident risk population (110 persons interviewed);

**Population 2**: Earthquake (natural catastrophe) risk population (96 persons interviewed).

Concerning this population we interviewed two different neighbourhoods concentrated in the same zone, 48 persons interviewed in each one. To complete the coping and stress scale we proposed people to answer it situated in to the industrial and the seismic risk situation.

**RESULTS**

We can see that stress is higher in population exposed to industrial accident (P1) than earthquake exposed population (P2) in global stress (4.654 p= 0.000) and the four dimensions of stress: psychological stress (5.247 p= 0.000), physic stress (4.025 p= 0.000), psychophysiological (4.484 p= 0.000), stress temporality (3.332 p= 0.001). Those results confirms our first hypothesis. We separated coping strategies in active and passive. We can observe that the variation in use of coping strategies only exists for the passive strategies (t= 5.596 p=.000), active are not significant (t=.449 p=.654). This result goes along the same lines as our second hypothesis. We analysed relationships between subjective probability,
external confidence degree and insecurity feeling of risk perception with the five stress dimensions (Bravais-Person's correlation coefficient). We can see that global and industrial insecurity feeling are significantly linked to the whole of stress dimensions (p= .000 and .001); behavioural insecurity is relied to almost all stress dimensions (p=.024 et .055) except to physic stress; and subjective probability is correlated only with temporality stress (p= .057). Priority risk and stress was analysed with a variance analysis method (Anova). We observed that the three priority risks are significantly linked to five stress dimensions : global (F= 7,66 p= .001), psychological (F= 6,06 p= .003), physical (F= 9,63 p=.000), psycho-physiological (F= 5,09 p= .007); temporality (F= 5,25 p= .006). The median differences between the three priority risks shows that industrial dangers has the highest level of stress, behavioural dangers the medium level and social-environmental risks the lowest (example for global stress : industrial m= 88,83; behavioural m= 72,89; social-environmental m= 67,47). Relationships between external-internal control and stress has also significant results: global 6,199 (p= .050), physique (.940 (p= .053) and temporality stress (3,977 p= .027) are linked to external-internal control; psychological and psycho physiological stress are not linked. In all cases we can see that individuals having an internal control develop the highest level of stress.

Concerning relationships between coping strategies and risk perception we observe that, in general, insecurity feeling is significantly linked to coping strategies: global is related to every dimension (p= .001 to .042); industrial is relied to four strategies : focalization (p= .001), social support (p= .011), retraction (p=000) and rejection (p= .000); behavioural is linked to retraction (p=.006) conversion (p=.054) and rejection (p= .036) and social-environment only with focalization (p= .013). External confidence degree is significantly related to conversion (p= .011) and control (p= .053). Subjective probability have not relationships with any coping strategy dimension. The three priority risks relationships with coping were analyzed with a variance analysis test (Anova). We found that priority risks have a significant relation with rejection strategies (F= 5,751 p= .004). Taking in to account the nature of the priority, individuals who have choose industrial risks has the highest median (m= 19,15), social-environment is after (m= 16,16) and behavioural has the lowest median (m= 15,59). External-internal control was analysed too (T student) and we observed that it is related only with social support (T= 1,213 p= .000) and active coping strategies (T=.364 p=.052). In both cases externals use more these strategies than internals.

DISCUSSION AND CONCLUSIONS
An important contribution of this study is the proposition of a model of cognitive risk perception process and the finding of risk perception modalities linked to stress and coping. The analysis of variability in two populations exposed to two different extreme risk situations have shown that stress level is higher in people exposed to an industrial accident (P1) than people exposed to a seismic risk (P2). At the same time, the first population utilise also better passive coping strategies than the other population. This rapport is observed in all relations between stress and coping. So we can translate it in the sense that the higher the level of stress is, the more passive coping strategies are. We have already advanced a possible explanation in our hypothesis : industrial risks are more visible to people because of the material presence of factories, industrial wastes, bad odours and pollution in general. All those risk manifestations are present everyday and people have to learn to live with them. That can be a reason for higher level of stress in contrast to the other population that does not have any material presence of the earthquake risk. Moser and Lidvan (1992) have already talk about the importance of visual information (environmental and situations) which are able to entertain or produce the insecurity feeling and guide the adoption of specific behaviours like fear.
We have seen that global, industrial and behavioural insecurity feeling, priority risk and external-internal control are related to most of stress dimensions. This confirmation can be an evidence of the influence of risk perception in the development of stress. Insecurity feeling is most correlated to coping, so we can think that risk perception influence the variability of coping with stress situations. Control (external-internal) in risk perception have shown that internals are more stressed and they applied more passive strategies than externals. In this case we have an hypothetical interpretation: facing to an extreme risk, internals make conscience of the reality of risk and the limits of their own possibilities, so they are more stressed and passive than externals. We find again the relationship between stress and passive strategies. We cannot know much about it but it can be explained by people ignorance, sense of belonging to the place they live, economical impossibility to move or negligence. These results can confirm our third hypothesis. We confirmed the variability in the development of stress and strategies applied to face a risk in two risks situation. Those differences cannot be explained only by the nature of risk people are exposed. Risk perception of individuals influences those variables to cope with danger. We have to consider those evidences to develop other researches in psychological field.

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MENTAL HEALTH EFFECTS FROM RADIATION: FACTS AND SOCIAL MANAGEMENT

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ABSTRACT
Mental health effects resulting from exposure to radiation have been identified principally in the context of large radiological accidents. They cover an extended scope of manifestations in relation with the notion of stress: increase of some hormones, modifications in mental concentration, symptoms of anxiety and depression, psycho-somatic diseases, deviating behaviours, and, on the long term, a possible post-traumatic stress disorder (PTSD). The main results come from the Three Mile Island, Goiania, and Chernobyl accidents and several modifying factors have been identified.

Considering those facts, diverse social responses can be brought to reduce the detriment to affected individuals and communities. Medical treatments are necessary for persons who suffer from pathological diseases. In most cases, a structured public health follow-up is required to establish the seriousness of the health problems, to forecast the extent of medical and psychological assistance, and to inform people who express fears and worries. Social assistance is always valuable under various forms: financial compensations, preferential medical care, particular advantages concerning working and living conditions. If this social assistance is necessary and helpful, it also induces a loss in personal adjustment capability and initiative capacity. To overcome those negative impacts, some guidelines to authorities’ action can be set up. But the best approach, not excluding the previous ones, remains problem solving at the local level through community responsibilization; some instructive examples come from the Chernobyl experience.

MENTAL HEALTH EFFECTS AND THEIR MODIFYING FACTORS
In interviews, individuals who suffered from a radiological accident show not only concern and worry, they insist upon the threat to their safety; they relate all their present health problems to radiation, the doses of which they do not know or doubt; they live in the threat of possible delayed effects. Some of them confess fears. Their well being has changed, as observed in self-assessed questionnaires. Regarding behaviour, demoralization affects many individuals. Life style is modified with changes in food consumption, substance abuse (alcohol, tranquilizers, sleeping pills), suppression of some activities, and new habits due to community disruption. Somatic complaints, as measured by symptom checklists, are reported. Coping actions of individuals range from apathy, avoidance, denying, information seeking, search for a culprit, to leaving for other areas. These individual reactions are more or less extended and intense, depending on the size of the accident, the distance from the accidented site, and the overall social context at the time of the accident. Individual reactions increase when social disturbances exist.

For the Three Mile Island accident, reactions in the local community increased sharply after the accident and dissipated rapidly. Few manifestations of chronic stress were observable one year after among the mothers of young children living close to the TMI nuclear plant. For the Chernobyl accident, all reactions remain at a high level in the groups of people concerned (communities evacuated or living in regions under strict radiation control, patients, plant personnel, liquidators), and their evolution over time has been studied. Their persistence cause
long term mental health problems. An excess of symptoms related to sub-clinic pathologies is likely to exist among the personnel of the nuclear plant and some PTSD manifestations are probable among the liquidators. Psychological distress, as a feeling mixing despair, depreciation and deterioration of own health, is obvious. Distress is not equally distributed. Worsening factors have been identified; an old age, difficult living conditions, to be relocated, mother with young children, the loss of social marks contribute to emphasize the individual detriment. For a detailed review, see [Pirard et al., 1998].

MEDICAL RESPONSES
Some persons show real somatic diseases and more or less severe chronic symptoms of psychological distress which need treatment by medicine doctors, psychiatrists or psychologists. Persons affected are not only victims, they are patients. As seen before, most of them are found among first days intervenors, liquidators, plant workers and mothers of young children. To solve these painful situations, an important medical team with extended skills must be installed in case of a large accident.

PUBLIC HEALTH FOLLOW-UP
People well being will be damaged in many ways and for a long period of time. Impacts on mental health, risky behaviours, demands for treatment may vary dramatically over time. Public health authorities must follow the evolution of health indicators and obtain dosimetric information, at the individual level preferably, for the affected populations. This is necessary for three main reasons. The first one is knowledge about the seriousness of the health problems. The second one is to forecast the need of medical and psychological assistance. Medical support must be organized and provided by medical institutions, as regional hospitals, clinics, specialized dispensaries, radiation protection units, health resorts and sanatoriums...The third reason, and maybe the most important one, is to give answers to people who express fears and worries that are, by experience, not always well founded. Rumors and distortions amplifying the consequences are common in the aftermath of a large accident.

Only a structured public health follow-up can give responses based on observed facts, to people and the media. The efficiency of a sanitary follow-up, or of an epidemiological survey (it is a better device, when possible), depends in great part on the authorities' capacity to activate the system as soon as possible after the accident and to keep it in operation for many years [Verger, 1997].

SOCIAL ASSISTANCE
It is well known that displacement of people has critical impacts on their psychism, social status and cultural habits, especially among the elderly. Displaced people express a very strong desire to return to the native land, even though it is contaminated and would endanger health and life. Evacuation and resettlement only solve the physical problem but do not reduce the level of social and psychological stress, because they create a series of new problems linked above all to the hardships of adjusting to new living conditions.

Populations living in contaminated territories suffer from a damaged environment and a greatly affected economic and social development. These consequences can be partly reduced by the implementation of an emergency programme under state supervision. Special laws must be adopted which provide the affected populations with compensation payments for the damage inflicted to their health and property, with preferential medical care, and with
compensations and privileges for their working and living conditions. There is no doubt that such a programme is necessary and helpful, but also extremely costly and unsustainable in the long term, particularly when the state has few resources. No doubt also that populations concerned become assisted and lose adjustment capability and initiative capacity. The biggest challenge is then to restore people self confidence and trust in changing their own future, in brief to provoke the profitable move from a passive attitude to a voluntary management of the problems they are facing.

GOVERNMENT ACTION GUIDELINES
The analysis of large nuclear accidents (Three Mile Island, Goiania, Chernobyl) carries out information on how public authorities, at the national or regional government level, managed the accident. Their actions to protect the public led to positive results but also negative ones. Applying pre-established radiation protection dose criterias, and even making them more severe as in the Chernobyl case, did not significantly modify the social acceptability of the situation. Communication was always deficient in the acute phase of the accident and increased personal anxiety and the distrust in authorities. How to make people tolerate the post-accident situation, which is in some ways a positive attitude? How to avoid rejection, which throws people into despair and depression? Some aspects connected to the return to « normality » are pointed out in [Lochard and Prêtre, 1994]. The temporal aspect refers to the many years that are necessary to observe an appreciable decrease of the soil contamination, which looks like a no end process. The zoning, justified and useful to protect against radiation, creates ghettos. The land is marked but the population too; there are those who live in and those who stay out. The reference to the dose limit for normal conditions is prominent in people’s minds and it constitutes the final goal to reach to end with this nightmare. To account for these aspects, the authors propose some general guidelines for government action:

1. The acceptability of the situation by the population directly affected by the contamination is largely dependent on its confidence in the ability of the system to restore tolerable conditions and to progress toward normality within a reasonable period of time.

2. One main concern of the affected public is to restore, as much as possible, normal living conditions in order to avoid the ghetto effect induced by the zoning of areas and by different treatment from the rest of the population.

3. For society, a key parameter is the duration of exceptional conditions. These conditions cannot last too long in order to maintain the feeling of time as a cyclic rather than a linear phenomenon.

4. From the radiological protection management point of view, except for the early phase after the accident during which the population is able to support exceptional levels of risk, the residual level of exposure is only tolerable if it remains close to the values considered for normal practices.

COMMUNITY RESPONSIBILIZATION
If some few individuals are able to recover personal confidence and reorganize positively their life, most of them are influenced by the ambient mood existing among their relatives and in their community. Stress can be reduced as the result of favourable conditions and of a problem solving positive behaviour adopted by the community. Representations of the contamination can evolve then. Contamination can be dealt with at the community level only when it is recognized, identified and associated with particular places, particular activities, particular living habits. This implies that the community is equipped with instruments measuring radiation and knows the technical solutions to reduce or avoid the doses. Some
successful experiences of a responsible management at the community level exist in Russia, Belarus and Ukraine. Two of them will be briefly mentioned.

One initiative is the creation by UNESCO of the Chernobyl Community Centres: Nikolskaya Sloboda, Uzlovaya, and Bolkhov in Russia; Alsokovshyna, Strechyn, and Pershey in Belarus; Borodyanka, Slavutych, and Yvankyy, in Ukraine. Their programme is defined as follows:

«The psychological objectives assigned to the Centres are: to improve the mental health of all age and social groups in the community; to promote family cohesion and parenting skills; to favor interactions within the community; to empower community members and encourage them to take control over their lives; to develop social responsibility; to promote problem solving. ... the Centres’s staff continually re-define the range of their activities according to the needs and demands of the specific communities in which they are located. Their actions come under four broad categories: case work, with a focus on individual and family therapy; group therapy for adults and adolescents with special attention to the needs of at-risk groups; play and art-therapy for children and adolescents; social support through empowerment and capacity building at the community level with the creation of local organisations, neighbourhood groups and associations. » [Garnets, 1996].

The project ETHOS in Belarus, under supervision of the CEC, is an other example of a community based approach to solve problems arising in a contaminated territory. In the small village of Olmany (Stolyn district), the project aims at helping the residents in the search of rehabilitation actions which ensure radiological protection and favour new living conditions. Various groups in the community are in charge of improving life at their own level. Milk producers control their own milk, and optimize the ways to feed the cows in order to respect the milk sanitary limit. Young mothers must improve the radiological situation of their children. So, they first worked to reduce the external exposure of children, measuring doses due to the deposits in all the places. Also, they considered the consumption of foodstuffs and modified, consequently, their family diets. Meat producers reduce the radionuclide concentrations in meat. Adolescents of the village are solicited to propose a new image of the village. Teachers are involved in learning about radiation management. Each group has to improve one particular domain that could be useful to the others members of the community [Hériard-Dubreuil, 1996]. This approach, more sociological than psychological, privileges the action, which is seen as the better way to avoid people to focus on their personal worries and disadaptations, and to escape their mental distress.

**CONCLUSION**

Large radiological accidents provoke more than changes in perceptions. They lead to psychological problems that are now clearly identified and whose extent is both severe and durable in the affected populations. There are no obvious means to reduce psychological distress when it is established. Among the possible responses, the best one remains the restoration of self confidence which allows individuals in their community to re-think a better future.

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RISK FACTORS FOR POST TRAUMATIC STRESS SYMPTOMS 5 YEARS AFTER THE 1992 FLOOD IN THE VAUCLUSE (FRANCE)

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In september 1992, a flood in the Vaucluse (France) resulted in 38 deaths. To evaluate its long term psychological impact, a telephone survey was carried out in 1997 in Bédarrides, a 5 000 inhabitants municipality, where no death did occur during the flood despite severe consequences. Only people residing in Bédarrides and older than 18 years at the time of the disaster were included in the study. After random selection of the households from the telephone diary, individuals were selected using the birthday method. A questionnaire detailed the exposure situations during the flood and the consequences. Symptoms of PTSD were assessed using a structured questionnaire based on DSM-IV criteria. Multiple regression analysis was performed to explain the PTSD score.

Five hundred individuals were interviewed with a response rate of 80%. The sample included 274 women (55%) and 298 individuals older than 44 years (60%). A significantly higher PTSD score was observed for females, subjects older than 35 years, household with a monthly income lower than 9 000 FF, subjects with a history of psychological disorders and subjects previously exposed to another flood. These variables were included in the multiple regression model as adjustment variables. The exposure dimensions most associated with a significant increase of the PTSD score were: self physical threat or physical threat of a next of kin (p<0.001), use of medical services during the flood (0.001), job loss after the flood (p<0.035), loss of a pet (0.042). No association was observed between the PTSD score and property damages due to the flood (p=0.46). A significant exposure-effect relationship existed between the PTSD score and a score cumulating the various exposure situations (p<0.001). These results, compatible with published results, suggest a possible long term psychological impact of the 1992 flood on the Bédarrides population.
MENTAL RISK AMONG CHILDREN IN BELARUS EXPOSED IN UTERO FOLLOWING THE CHERNOBYL ACCIDENT

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ABSTRACT

The study examined psychological development in 250 children at the age of 6–7 and 10–12, who had exposed in the prenatal period at the time of the Chernobyl accident in 1986. These children were compared to a control group of 250 children of the same age from non- and slightly contaminated areas of Belarus. The examination included psychiatric examination and intellectual assessment as well as the estimation of thyroid exposure in utero. The children of the exposed group had a lower mean full-scale IQ compared to the control group (89.6±10.2 vs 92.1±10.5 at the age of 6–7, $P=0.007$). By the age 10–12 years there were no statistically significant distinctions between mean IQs of the exposed and control groups (94.3±10.4 vs 95.8±10.9, $P=0.117$). The relative risk of mental and behavioural disorders has been estimated for emotional disorders $OR=2.67$, $P<0.001$. The frequency of the formation of mental retardation, learning disorders, hyperkinetic disorders and other mental and behavioural disorders in children from both groups was approximately the same.

INTRODUCTION

The accident of the nuclear power plant in Chernobyl in the northwestern Ukraine, on 26 April 1986, released large quantities of radioactive materials. The radioactive cloud, which reached the territory of Belarus within a few hours after the accident, contained a large amount of various radioiodine isotopes that resulted in high radiation doses to the thyroids of the population. There are scanty data in the literature concerning the neurological and psychological status of the children exposed to the influence of radionuclides during the prenatal and neonatal period as a result of the Chernobyl accident. One factor that may cause these disorders is prenatal exposure of the thyroid gland to radioiodine. The absorbed doses are 2–3 times higher in the developing thyroid gland of embryo and fetus than in the thyroid gland of the mother. Radiation affecting the thyroid gland leads to involvement of other endocrine glands in the pathological process through the thyroid gland-hypophysis-hypothalamus. This may cause psychological retardation, retardation of the central nervous system maturation, low psychological and emotional development and other mental disorders [1]. The possible negative effect of radiation on the psychological development of children can be intensified by unfavourable psychosocial factors such as forced migration or adaptation to new conditions of living in the stricken area. Thus it is necessary to take into account both biological (pre- and postnatal influence of radionuclides and other exogenic factors) and psychosocial factors when estimating the influence of the Chernobyl accident and its effects on the psychological development of children.

MATERIALS AND METHODS

Participants. The exposed group was 250 children, born during the period from May 1986 to February 1987. During the Chernobyl accident their mothers lived in the settlements with $^{137}$Cs soil deposition densities ranged from 100 to 15400 kBq·m$^{-2}$. Among them mothers of 14 children lived in town Pripyat (Ukraine) and were evacuated in Belarus shortly after the
accident. The control group was formed by means of random selection and consisted of 250 children who were born in the period from May 1986 to February 1987. Their mothers had constantly lived in non- and slightly contaminated areas of Belarus in the settlements with $^{137}$Cs soil deposition densities ranged from 0.2 to 200 kBq·m$^{-2}$.

There are nor statistically significant differences in age and sex structure (See Table 1) as well as in educational level of parents in between exposed and control groups. Also there were no relevant distinctions of social status of parents of the children belonging to the exposed and control group. It should be noted that parents of children from the control group had had no professional contact with sources of ionizing radiation.

Table 1. Age and sex distributions of children of exposed and control groups

<table>
<thead>
<tr>
<th>Gestation period, weeks</th>
<th>Number of children in</th>
<th>Comparison between groups, $P$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>exposed group</td>
<td>control group</td>
</tr>
<tr>
<td></td>
<td>$M$</td>
<td>$F$</td>
</tr>
<tr>
<td>0-7</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>8-15</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td>16-25</td>
<td>29</td>
<td>26</td>
</tr>
<tr>
<td>&gt; 25</td>
<td>33</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>124</td>
</tr>
</tbody>
</table>

Medical and psychological examination. The psychiatric examination of the children of both groups was performed by means of semi-structured clinical interview based on the diagnostic criteria of ICD-10, chapter V (Mental and behavioural disorders). The intellectual development of the above children was examined by means of psychological testing using the Wechsler Intelligence Scale for Children - WISC-III UK [2].

Dosimetry. Thyroid doses was estimated for children exposed in utero based on results of individual thyroid dose estimate for the mother and a transfer coefficient from mother’s to the foetus that takes into account the period of gestation at the time of exposure [3]. For mothers evacuated shortly after the accident from town Pripyat thyroid dose estimates based on results of [4]. For other persons only thyroid doses due to $^{131}$I ingestion have been considered in our paper. Thyroid doses from iodine ingestion have been reconstructed on the basis of results of $^{131}$I thyroid activity measurement (if such data were available for mother of child included in the study) and applying of an $^{131}$I environmental transfer model adapted to Belarusian conditions. The detail description of methods used for $^{131}$I thyroid dose reconstruction can be found in [5,6]. To estimate the individual thyroid dose information about the life-style of the mother during the iodine period was obtained by personal interview.

RESULTS AND DISCUSSION

Thyroid doses. For 64 children from exposed group and for 72 children from control group thyroid dose was estimated to be zero. It is due to the fact that gestation age of the foetus at the time of the accident was less than 10 weeks and there was not of uptake of $^{131}$I by undeveloped thyroid. Means and medians for those distributions are exposed group, 0.39 and 0.23 Gy; control group, 0.04 and 0.01 Gy. Means of thyroid doses for the control group is significantly lower that for exposed children ($P<0.001$). Among the children of exposed group the maximal individual dose of exposure to the thyroid gland is estimated to be 4.1 Gy.
Table 2 compares the children from exposed and control groups in the terms of the three specified above dose intervals. As in the comparison of mean thyroid dose those two groups differ significantly, the odds ratio for the lowest dose interval compared to the two highest dose intervals (OR=41.7) shows strong relationship between prenatal thyroid doses and exposed/control status of children.

Table 2. Comparison of thyroid doses of children of exposed and control groups

<table>
<thead>
<tr>
<th>Thyroid dose interval, Gy</th>
<th>Exposed group</th>
<th>Control group</th>
<th>Total</th>
<th>$\chi^2$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.3</td>
<td>135</td>
<td>245</td>
<td>380</td>
<td>132.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>0.3–1.0</td>
<td>95</td>
<td>5</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 1.0</td>
<td>20</td>
<td>250</td>
<td>270</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IQ test results. At the age 6–7 the children of the exposed group had a lower mean full-scale IQ compared to the control group (89.6±10.2 vs 92.1±10.5, $P=0.007$). We found that the children of the exposed group had a relatively more cases of a low average range of full-scale IQ (IQ=80–89) as compared to the control group. Clinically low average range was

Table 3. Prevalence rates of mental and behavioral disorders among children

<table>
<thead>
<tr>
<th>Mental and behavioral disorders</th>
<th>ICD-10 code</th>
<th>Exposed group</th>
<th>Control group</th>
<th>$\chi^2$</th>
<th>Odds ratio (OR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild mental retardation</td>
<td>F70.9</td>
<td>5</td>
<td>5</td>
<td>1.0</td>
<td>1.00</td>
</tr>
<tr>
<td>Specific developmental disorders of speech and language</td>
<td>F80</td>
<td>20</td>
<td>8.0</td>
<td>12</td>
<td>4.8</td>
</tr>
<tr>
<td>Specific developmental disorders of scholastic skills</td>
<td>F81</td>
<td>18</td>
<td>7.2</td>
<td>13</td>
<td>5.2</td>
</tr>
<tr>
<td>Specific developmental disorders of motor function</td>
<td>F82</td>
<td>11</td>
<td>4.4</td>
<td>6</td>
<td>2.4</td>
</tr>
<tr>
<td>Disturbance of activity and attention</td>
<td>F90.0</td>
<td>12</td>
<td>4.8</td>
<td>11</td>
<td>4.4</td>
</tr>
<tr>
<td>Emotional disorders with onset specific to childhood</td>
<td>F93</td>
<td>45</td>
<td>18.0</td>
<td>19</td>
<td>7.6</td>
</tr>
<tr>
<td>Disorders of social functioning</td>
<td>F94.0</td>
<td>12</td>
<td>4.8</td>
<td>9</td>
<td>3.6</td>
</tr>
<tr>
<td>Transient tic disorder</td>
<td>F95.0</td>
<td>16</td>
<td>6.4</td>
<td>12</td>
<td>4.8</td>
</tr>
<tr>
<td>Others</td>
<td>F98</td>
<td>23</td>
<td>9.2</td>
<td>17</td>
<td>6.8</td>
</tr>
<tr>
<td>One or more diagnoses</td>
<td></td>
<td>101</td>
<td>40.4</td>
<td>62</td>
<td>24.8</td>
</tr>
</tbody>
</table>

* 95 % confidence interval

characterized by moderate disorders of gnostic processes, poor motivation and the lack of intellectual prerequisites (active attention, short-term memory, constructional functions, etc.).

By the age 10–12 years there were no statistically significant distinctions between mean IQs of the exposed and control groups (94.3±10.4 vs 95.8±10.9, $P=0.117$) and between IQs of the exposed and control groups.
**ICD diagnoses.** The prevalence rates of mental and behavioural disorders among the children of exposed and control groups are shown at Table 3. The relative risk of mental and behavioural disorders has been estimated as the ratio of chances (odds ratio). As can be seen from Table 4 the relative risk of the development of emotional disorders is estimated to be OR=2.67 (P<0.001). The frequency of the formation of mental retardation, learning disorders, hyperkinetic disorders and other mental and behavioural disorders in children from both groups was approximately the same.

**REFERENCES**


TRACK 5

SESSION 7

ECOLOGICAL/
ENVIRONMENTAL
HEALTH RISKS
TRACK 5
SESSION 7
ECOLOGICAL
ENVIRONMENTAL
HEALTH RISKS
QUANTIFICATION OF RISK FOR ECOSYSTEM SURVIVAL

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Quantification of risk for ecosystem survival requires to find out such parameters which could characterise ecosystem as a whole. Describing the response of ecosystem to any external factor it is necessary to take into account: (1) the changes in the energy balance (2) the changes in the composition and structure of the ecosystem and (3) changes in the compensatory potential of ecosystem, as the ability to restore the original composition and structure after cessation of stressor action. In our approach one of the quantitative characteristic of ecosystem stability will be prosperity function, $P$, which we will introduce as a difference between the ecosystem energy assimilation ($dE$) and total energy spent ($dR$) on the respiration, competition, life activities etc. Risk to the energy balance of ecosystem may be characterized by the relative change of the prosperity function of the community. On the other hand also, the decrease in species variety and increase in the dominance of some species in the ecosystems will be typical response on the action of stressors. The most suitable quantitative characteristic of these effects will be the Shannon index, $H$ for the species diversity, which shows the degree of smoothness of species composition. If to define the index of relative risk of the ecosystem destruction due to the changes under action of stressor as “$q$”, and the rate of ecosystem restoration as “$h$”, then the comprehensive risk index for ecosystem due to the changes of the prosperity function and the species diversity at moment $t$ could be defined as:

$$q(t) = (1 - \frac{H_s}{H_m}) \cdot (1 - \frac{P_s}{P_m}) \cdot e^{-ht}, \quad (1)$$

where index “$s$” means the values in case of stressor influence, and index “$m$” means the maximal value in case of natural optimal conditions. Here $P$ is the prosperity function. The means and ways to find out the values of prosperity function, Shannon index and some examples of methodology application will be given.
A FRAMEWORK FOR ASSESSMENT OF POLLUTION RISKS: A GUIDE TO INSURERS

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ABSTRACT
The growing interest on the development and application of pollution insurance systems is mainly justified by the high potential of this tool for ecological risk management. However, the development and implementation of such systems can be troublesome, mainly due to difficulties in identifying activity risks, estimating damage magnitude and in the monetary valuation of those ecological damages. We propose an iterative, cost-effective, framework linking economic valuation methods to ecological risk assessment methodologies, intended to serve as a guide to support insurers on the assessment of pollution risks. The framework is illustrated in a hypothetical case study.

1 - INTRODUCTION
Insurance allows risk transfer from a person or enterprise to an insurance company, which in turn receives an insurance premium that reflects the number and type of covered risks, coverage of expected costs and insurance profit.

A market and an insurance system prepared for new products of pollution insurance are required, although actual environmental liability regimes and the lack of awareness of potential clients to pollution problems makes its development and implementation difficult. Other contributors to these difficulties are the significant increase of claims related to environmental disasters, the scarce monetary valuation of ecological damages and the lack of specialized departments in environmental risk. This last aspect is related with understanding uncertainty, identifying and quantifying risk, and responding to risk that are core strengths for insurers in managing environmental problems [12].

Therefore, environmental risks are usually seen as financial and business risks by the insurance industry, which is reflected in the kind of coverage that insurers are willing or unwilling to provide, as well as in the price of this coverage. [8], [12].

To tackle these problems, we propose an iterative and cost-effective framework, intended to serve as a guide to insurers on the assessment of pollution risks, resulting from accidental situations in different activities. These situations are characterized by their short-duration and by generating acute effects as main response.

2 - PROPOSED FRAMEWORK
The proposed framework consists in a joint methodology that links ecological risk assessment to economic valuation of environmental damages to support and provide information to
insurers for premium calculation as well as compensation and recovery amounts estimation (Figure 1). The strategy inherent to the entire framework involves balancing the expected costs of potential losses against the costs of quantifying and reducing them. This cost-effective approach allows the identification of the point where the costs of additional data exceed its potential of improving decision(s) to be made.

![Figure 1 - Proposed framework](image)

2.1 – Risk Assessment Methodology. The risk assessment methodology supports insurers on hazard identification and risk prediction resulting from pollution accidents.

Traditional forms of collecting information, by the use of questionnaires, are only adequate to the evaluation of traditional risks and very simple cases of pollution risks. Additionally, pollution insurance premiums cannot be based on a past claims register due to changes on legislation and/or to the constant identification of new contaminants and associated risks. Due to this, risk assessment and specifically ecological risk assessment, represents a tool with high potential to improve the evaluation of ecological risks.

The risk assessment methodology is based on EPA\(^1\) [4], [5], [6], [7], WERF\(^2\) [13] and LPC\(^3\) [10] guidelines. Five tiers of analysis are considered. The simplest use methods similar with the traditional ones, like questionnaires. The more complex approaches consist in applying ecological risk methods, ranging from deterministic to probabilistic analysis, where Monte Carlo Simulation is used. The higher tier also includes several methods of safety/engineering risk.

At the end of each tier insurers can decide to decline, underwrite the risks or proceed the analysis, taking into account risk and uncertainty magnitudes. This iterative procedure allows the insurer to take partial actions until desired levels of residual risk and uncertainty are achieved and while the costs of additional analysis justify its benefits in improving the judgment process.

The proposed methodology allows to estimate: a) the likelihood of occurrence of an accident; b) the likelihood and magnitudes of the resulting ecological damages; c) the uncertainty associated to the risk estimates; d) the selection of the most significant risks; e) the identification of potential victims and possible responsible parties in case of occurrence of an accident.

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1 EPA - Environmental Protection Agency
2 WERF - Water Environment Research Foundation
3 LPC - Loss Prevention Council
The obtained risk and uncertainty estimates are ranked in categories, each with numerical ranges of magnitude of damages and likelihood of occurrence. For risk estimates obtained in the higher tier, the associated uncertainty is also presented. An indication of the ecological significance of the identified injuries, determined based in criteria like vulnerability of the affected receptors, will be used to facilitate the selection of the most adequate economic valuation approach.

2.2 - ECONOMIC VALUATION METHODOLOGY. Risk assessment results are linked to economic valuation in order to estimate the monetary value of ecological damages. The damage magnitude (magnitude of injury and associated costs) is an essential input for premium determination.

The proposed methodology consists in a procedure that is intended to guide the insurer in the strategy to follow and include four main steps: characterization of the ecological injury, identification of the change components of the total economic value (TEV), selection of the economic valuation approach and monetary value of the ecological damage.

The identification of the changed components of the total economic value of the environmental assets depends on changes on use and/or non-use values. Possible economic valuation methods must then be identified in order to estimate the monetary value of the change components. In spite of the availability of several methods, some objections can be raised to their practical application in the context of the proposed framework, due to the time and budget required for most studies. Benefit Transfer techniques, which consist on the transfer of existing estimates of non-market values to a new study (“policy site”) different from the one for which the values were originally estimated (“study site”) [2], have a high potential to avoid some of these problems.

Usually it is recommended to limit Benefit Transfers application to “minor” pollution incidents, where the costs of damage assessments exceed significantly the costs of expected ecological losses [3], [9], [1], mainly due to the high likelihood of significant uncertainty of the obtained estimates. [1]. Although benefit transfer is a “less than ideal” benefit estimation method, so are other valuation efforts in the sense that better estimates could often be obtained if more time and money were available [1]. Whenever possible, Benefit Transfers are the first approach to use independently of the magnitude and costs of expected losses, due to their particularly usefulness in providing rough economic estimates that may be sufficient to make a judgement [1] about the coverage of potential risks.

The procedure includes sets of criteria in several points of the process of Benefit Transfers application that must be taken into account in order to evaluate the quality of the final estimates of the “policy site”. Two reasons can lead to the need of applying a full economic valuation method: (1) Benefit Transfers cannot be applied due to the lack of adequate base studies, problems in the transfer of the “study site values” or the quality of these estimates and (2) The quality of the obtained estimates is not sufficient. In this case, the user is confronted with the relation between the expected losses and the costs of applying a full economic valuation method. At this point, the procedure includes a database of economic valuation studies covering characteristics like mean cost, total time spent and percentage of satisfactory results, in order to provide numerical ranges upon which users can base their decisions.
A monetary estimate of the early-identified ecological injuries is obtained, improving insurers confidence in establishing premium values to the insured party, compensation amounts to victims and recovery amounts.

3 - CASE STUDY
The framework is being tested on a case study that includes a section of a creek where several situations of fish mortality have occurred as a consequence of high chlorine levels released during accidental functioning of a plant, located in one of the stream margins. Several scenarios will be considered in terms of the characteristics of the species of fish at risk, in order to have situations with receptors with non-use and use values, respectively ecological and recreational value. The consideration of a hypothetical case study with two scenarios makes possible the application of different economic valuation approaches and thus test the framework.

4 - OTHER POSSIBLE USERS OF THE FRAMEWORK
Although the framework is designed for application in the insurance industry, its potential usefulness to insured parties and regulators is also being studied. The results obtained by the framework can provide to insured parties information about the levels of risk that they can be liable for and thus allow them to make trade-off evaluations between the several magnitudes that the premium value can take and the costs that they may incur. These are environmental-related costs and can include fines, expenditures on pollution control (measures to reduce risks), recovery costs (clean-up costs) and compensation (third party claims) costs. Additionally, the proposed framework can help regulators set minimum fines and other statutory penalties to responsible parties, in case of occurrence of ecological damages resulting from accidents, as well as to set minimum values for insurance coverage.

5 - CONCLUSION
The developed framework supports insurers on the assessment of pollution risks by providing information that increases their confidence in establishing premium values, as well as compensation and recovery amounts. The framework consists of an iterative cost-effective procedure that evaluates if expected losses justify the costs of a damage assessment.

The predictive potential of the framework associated to an uncertainty analysis represents a significant contribution to insurance companies that can early know the true meaning of risk estimates obtained for the candidate activities and decide to decline or underwrite those risks. Additionally the monetary valuation of the injuries can improve insurer decisions by providing an estimate of the costs that they may incur in covering some situations.

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BIBLIOGRAPHY
THE ASSESSMENT OF PRIORITIES FOR MIDDLE URALS' ENVIRONMENTAL POLLUTION PREVENTION

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ABSTRACT
The environmental problems of the Ural industrial region are of such magnitude, seriousness, and urgency that the limited available resources can be applied only to the problems of the highest priority in the most cost-effective way. A methodology based on risk assessment approach was developed to establish Russian priorities for practical pollution prevention measures. Main environmental problems were assessed and ranked, effectiveness of various pollution prevention measures on local and regional level were compared and prioritized on the basis of their effectiveness and cost. Administrative district, city or town was used as a structural unit while developing the methodology on the regional (Oblast) level. Such a unit is characterized by environment impact and environment quality parameters. A system of indices and indicators was designed to compare and prioritize environmental problems. Environmental health risk assessment methodology was used for developing the local-level methodology for environmental pollution prevention.

The paper presents the intermediate results of the ISTC Project #500-98 (March 1, 1998 - August 31, 2000). The Project is supported by the European Community.
Main objectives of the project are to develop and apply a methodology to establish Russian priorities for practical pollution prevention measures in a limited geographic region of the Middle Urals (Chelyabinsk Oblast and Sverdlovsk Oblast). The project will assess and rank the main environmental problems, estimate and compare the effectiveness of various pollution prevention measures (on local and regional level), and prioritize them on the basis of their effectiveness and cost. This methodology will be developed on two geographic levels: local (enterprise scale) and regional (territory scale).

Sverdlovsk and Chelyabinsk Oblasts are among the most environmentally unfavorable regions of Russia. The main reason of such situation is the extremely high concentration of environmentally dangerous industries – that is, the mining and processing of mineral resources (coal, iron and copper ore) which are used in the production of heavy machinery. The other reasons are that the region’s vast mining and metallurgical combines are outmoded, lack of pollution control technologies, poor exploitation of existing equipment for pollution control.

By the total emission of toxic substances from stationary sources of air pollution Sverdlovsk and Chelyabinsk Oblasts take first and second places in the Urals Economic Region. In 1996 the share of Sverdlovsk and Chelyabinsk Oblasts in emission of air pollutants were 31% and 21% of total all-Urals emission respectively.

By the amount of contaminated waters discharged into rivers and natural reservoirs Sverdlovsk and Chelyabinsk Oblasts are leaders in the Urals Economic region (33% and 29% of total sewage discharge respectively).

Serious environmental problem is industrial and municipal waste accumulation. The largest amount of industrial wastes is generated in mining and metallurgical industries.
Environmental impact of agricultural sector of economy is not very intensive. Intensive emission/discharges of pollutants and generation of a large deal of toxic wastes have led to high levels of contamination of air, surface waters and soils at a significant part of the Sverdlovsk and Chelyabinsk regions.

Air contamination in the largest industrial cities of the Urals exceeds Russian maximum permissible limits. Every year the Russian Ministry of Environmental Protection includes such Urals cities as Ekaterinburg, Kamensk-Uralski, Nizni Tagil (Sverdlovsk Oblast), Chelyabinsk, Magnitogorsk (Chelyabinsk Oblast), in the list of cities with the highest level of air contamination in which the average annual concentrations of benz(a)piren, formaldehyde, nitrogen oxides exceed Russian standards in 2-10 times. It means that more than 60% of population of Sverdlovsk and Chelyabinsk Oblasts have living conditions that don’t answer sanitary standards.

Most of water objects of the region are also contaminated up to the levels significantly exceeding Russian standards. In the most contaminated rivers the average annual concentrations of water contaminants often exceed maximum permissible levels by factors of tens and thousands.

High anthropogenic burdens have caused soil contamination of settlements and agricultural lands. For the Chelyabinsk and Sverdlovsk Oblasts not only chemical contamination is typical, but also high-level radioactive one.

Environmental problems of the region were ranked on the basis of two approaches: that that uses various sets of indices and indicator and methodology of environmental health risk assessment.

The officially accepted techniques for ranking territories by integral indicators of the environmental troubles are poorly developed in Russia. The approaches used for this ranking are based on indicators of the environmental impacts and environmental indices or on their combination:

- criteria based on mass and toxicity of pollutants that are emitted in atmospheric air and discharged in surface waters, mass and toxicity of industrial wastes;
- criteria based on the ratio of concentration of toxicants in air, water and soil to their reference concentration;
- criteria based on more complex indices that are combination of data on environmental impact, environmental quality, environmental protection activity, population health, etc.

In this Project we have used a new approach for constructing the unitless integral indicator of the environmental stress. This indicator integrates 3 types of indicators:

- indicators of environmental impacts (for example, releases of contaminants to air, discharges of contaminants to surface waters, solid waste generation, man-made burden to area, etc.);
- environmental state indices (for example, quality of air, surface waters, soil contamination levels, status of ecosystems, etc.);
- indicators of the public response to the environmental changes (for example, the annual investment in the environment protection, total penalty for environmental contamination events, etc.).

Since values of the indicators are incomparable due to different origin, scale and units, they are reduced to the standardized indicators of the following form:

\[ x_i^0 = \frac{x_i - M(x_i)}{\sigma(x_i)} \]  

(1)
where $M(x_i)$ and $\sigma(x_i)$ are respectively expectation and mean square deviation of the indicator $x_i$.

Then the standardized indicators were aggregated in the unitless integral indicator of the environmental status:

$$J = \sum_{i=1}^{n} w_i x_i^2$$

(2)

where $w_i$ is the weight coefficient related to the indicators, and $n$ is the number of chosen indicators. Numerical values of the weight coefficients are determined through expert assessment.

With this approach we have ranked major cities of Sverdlovsk Oblast.

To characterize intensity of environmental impact we used the following parameters:
- total emission of pollutants into the atmosphere from stationary sources;
- hazard index air pollutants;
- volume of discharged contaminated sewage water;
- sewage discharge hazard index.

For characterization of the state of environment the following three parameters were used:
- the air contamination index;
- the water contamination index;
- the soil contamination index.

To describe the public response to the environmental problems we used two values:
- annual lay out of funds for the local environmental foundation;
- investments in building of the environmental protection facilities.

Using the formulas (1) and (2) we calculated: the impact intensity index (all four weight coefficients were equal to 0.25); the state of environment index (weight coefficients of 0.33); and the public response index (weight coefficients of 0.5). Then these three indices were integrated in the integral index of the environmental stress, Table 1. In compliance with this approach, the most severe environmental troubles are in the cities of Pervouralsk, Nizhny Tagil and Revda.

<table>
<thead>
<tr>
<th>City</th>
<th>Environmental Impact Index</th>
<th>Environmental State Index</th>
<th>Public Response Index</th>
<th>Integral Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pervouralsk</td>
<td>0.60</td>
<td>0.03</td>
<td>1.95</td>
<td>1.32</td>
</tr>
<tr>
<td>Nizhny Tagil</td>
<td>0.98</td>
<td>0.31</td>
<td>0.77</td>
<td>0.52</td>
</tr>
<tr>
<td>Revda</td>
<td>-0.44</td>
<td>-0.21</td>
<td>-0.62</td>
<td>0.15</td>
</tr>
<tr>
<td>Kamensk-Uralsky</td>
<td>-0.50</td>
<td>1.20</td>
<td>-0.63</td>
<td>-0.03</td>
</tr>
<tr>
<td>Verkhnaya Pyshma</td>
<td>-0.59</td>
<td>-0.19</td>
<td>-0.72</td>
<td>-0.06</td>
</tr>
<tr>
<td>Krasnoturinsk</td>
<td>0.39</td>
<td>-0.68</td>
<td>-0.44</td>
<td>-0.59</td>
</tr>
<tr>
<td>Ekaterinburg</td>
<td>-0.43</td>
<td>-0.47</td>
<td>-0.31</td>
<td>-1.32</td>
</tr>
</tbody>
</table>

Besides this approach based on the development of generalized indicators, we also used an approach based on environmental health risk assessment methodology, developed by the U.S. Environmental Protection Agency.

We assessed the cancer risk resulting from air contamination with formaldehyde, benzene, benzpyrene and heavy metals. The lifetime individual excess (compared to spontaneous level)
cancer risk resulted from chemical contamination of air is maximal for the cities of Ekaterinburg and Nizhny Tagil making up the value of $6 \times 10^{-4}$. For comparison, currently in Russia the lifetime cancer risk is 0.17 for male and 0.18 for female. So, in Nizhny Tagil, the incremental cancer risk due to air contamination is 0.35% of the average spontaneous level in Russia. Calculated results for the population risk demonstrate that excessive as much as 1378 cancers caused by air contamination are expected in Sverdlovsk Oblast.

The cancer risk resulting from water contamination was assessed for chloroform and carbon tetrachloride. These chlorides are the result of chlorination of water with high content of organic substances. This problem is the most acute in the cities of Ekaterinburg, Nizhny Tagil, Ivdel, Krasnouralsk and Verkhnaya Pyshma. The individual cancer risk due to contamination of drinking water with chlorides is several factors lower than that due to air contamination. Contamination of drinking water with chlorides may cause as much as 260 incremental cancers in the whole Oblast, Table 2.

**TABLE 2.** Individual excess lifetime cancer risk due to environmental contamination, $\times 10^{-4}$, and population risk, expected number of excess cases in the exposed population

<table>
<thead>
<tr>
<th>City</th>
<th>Cancer risk due to air contamination</th>
<th>Cancer risk due to drinking water contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>individual</td>
<td>population</td>
</tr>
<tr>
<td>Asbest</td>
<td>0.76</td>
<td>6.3</td>
</tr>
<tr>
<td>Verkhnaya Pyshma</td>
<td>1.03</td>
<td>5.5</td>
</tr>
<tr>
<td>Verkhnaya Salda</td>
<td>6.03</td>
<td>770.5</td>
</tr>
<tr>
<td>Ekaterinburg</td>
<td>0.76</td>
<td>6.3</td>
</tr>
<tr>
<td>Ivdel</td>
<td>3.75</td>
<td>73.2</td>
</tr>
<tr>
<td>Kamensk-Uralsky</td>
<td>0.93</td>
<td>2.3</td>
</tr>
<tr>
<td>Kirovgrad</td>
<td>3.38</td>
<td>22.1</td>
</tr>
<tr>
<td>Krasnoturyinsk</td>
<td>0.98</td>
<td>3.3</td>
</tr>
<tr>
<td>Krasnouralsk</td>
<td>6.07</td>
<td>247.3</td>
</tr>
<tr>
<td>Pervouralsk</td>
<td>2.37</td>
<td>32.5</td>
</tr>
<tr>
<td>Revda</td>
<td>0.93</td>
<td>6.1</td>
</tr>
<tr>
<td>Oblast as a whole</td>
<td>1377.6</td>
<td>259.4</td>
</tr>
</tbody>
</table>

To select a territory to develop and test priorities methodology at local (town scale) level we take into account the following factors.
- The size of the town
- The degree of isolation of selected site from other territories.
- Availability of results of other investigations in selected site
- Existence of local, regional, Oblast, etc. environmental protection programs for selected site

It seems that the town Kamensk-Uralsky is the most suitable for developing and testing the methodology on the local level.
COMPUTER TECHNOLOGY FOR DEVELOPMENT OF OPTIMAL THERAPY AT THE ACTION OF TOXIC SUBSTANCES IN FOOD CHAIN

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ABSTRACT
The method of risk assessment of occurrence of pathologies caused by influence of toxic substances (TS) in food chain on immune system and disturbance of metabolism is offered. It is based on determination of loading on regulator mechanisms and their reserves. Loading is determined with the help of mathematical model of immune response, which takes into account regulation contours, describing influence of sorbents and others therapeutical means for removing TS from organism and efficacy of work of immune system. To account reserve opportunities of system the degree of metabolic disturbances is used. It is estimated on shifts in relation intensity of lipid exchange to intensity of carbohydrate exchange.

The software is developed to solve the following optimization tasks: 1) determination of dynamics of introduction of therapeutical preparations ensuring a given risk level; 2) determination of optimal therapy (application of interleukines, immunocorrectors and also sorbents) for removal of TS from organism, at which risk of pathological changes is minimized; 3) providing given power exchange at optimal ratio of fats and carbohydrates in organism. The dynamics of control influences (sorbents, interleukines, immunocorrectors, and also rates of arrival of fats, proteins and carbohydrates) ensuring risk minimization is determined. With the help of developed programs the task of automated compilation of nutrition ration is also solved. This ration provides an optimal ratio of fats, proteins and carbohydrates in organism at the given intensity of power expenditure.

The offered technology creates essentially new possibilities for rise of efficiency of immune and deintoxication therapy, as it allows: a) to calculate risk of occurrence of pathological changes on immune and metabolic parameters; b) to choice optimal complex therapies on dynamical integrated parameters; c) to develop quantitative criterions of estimation of using sorbents, radioprotectors and others therapeutical means minimizing negative consequences of influence of TS on organism.

THE MODEL FOR RISK CALCULATION OF POLLUTANT PATHOLOGIC EFFECTS IN FOOD CHAIN
Under influence of constant effects of low radiation doses (LRD) the loading on immune system of human organism steadily increases. One of the ways on radionuclides' penetration into human organism is the chain «source of pollution - environment - food product - critical organ - protective immunologic functions of human organism - immune status of organism». Accumulation of pollutants on cell level causes free radical accumulation, hyperlipoidemia, irreversible disturbances within intracellular structures, which causes to emergence of immunodeficient conditions. Immunodeficiency emergence can be tied up not only with increase of level of food chain pollution but also with so called metabolic immunodepression, provoked by disturbances in fat-hydrocarbon exchange.

Thus the solution of the task of normalization of immune status of organism can be carried out in three directions: 1) increase of reserve possibilities of immune system; 2) decrease of a
level of pollution due to radioprotectors and sorbents; 3) optimal choice of food ration, at which at the given level of PS consumption the violation in fat-hydrocarbon exchange is minimized and immune status is maximized. The calculation of risk of occurrence different immune deficiency, stipulated by influence of pollutants and metabolism disturbances, has the large significance for practical medicine. It can be carried out only due to use of software allowing considerably to increase efficiency of the analysis of medical-biological data.

In works [1] a method of risk assessment of prepathologic and pathologic conditions emergence in human organism (R) caused by radiation effects on its vital-important function was proposed. The risk assessment was based on valuation of immune system’s reserves by means of mathematical modeling of humoral immune response as well as regulation mechanisms’ intensity degree which are calculated for some form of acute leucose by means of regression analysis on the base of clinical symptoms, hemogram, myelogram and immunogram data for persons subjected to prolonged effects of LRD. In work [2] the method of risk assessment of pathologic conditions, caused by food chain pollutants’ effects on immune system and by metabolism disturbance was created. The intensity of regulation mechanisms was estimated by means of immune organism status (IOS), which is calculated on the base of mathematical model of cell immune response. It permits to study dependence of immune system reserve possibilities on absorbed radiation dose level, effect of sorbents and other therapeutical means on pollutant removal from organism and efficiency of immune system functioning.

For calculation of reserve possibilities the metabolic disturbance degree was used. It evaluated by shifts in ratio of lipid exchange intensity to hydrocarbon exchange intensity. Let \( D_0 \) be the above ratio corresponding to the data put into the model, \( D_{\text{opt}} \) - its value corresponding to norm. With the increase of this ratio a gradual reduction of reserve possibilities occurs. One of the possible ways of calculation of this ratio dynamics as a function of processes of synthesis, transformation and utilization of energy is mathematical modeling of above processes. The mathematical model was elaborated for calculation of this ratio dynamics as a function of processes of synthesis, transformation and utilization of energy. For risk calculation one of universal deformation of catastrophe theory - cusp - was used. The risk value (R) was determined by the following way: \( R = \frac{10S}{10S_H} \), where \( 10S_H \) is the critical level of IOS, on reaching of which a pathologic condition emergence risk sharply increases.

THE CALCULATION OF OPTIMUM SCHEMES OF REMOVAL OF POLLUTION FROM FOOD CHAIN

In this work software was worked out which provide by means of above mentioned models for solution of following optimization problem: finding out of optimum therapy connected with application of interleukins and immunocorrectors as well as sorbents for radionuclides’ removal out of organism which minimize pathologic change risk; 2) estimation of model parameters dynamics corresponding to the given risk level. In the course of optimum control task solution dynamics of control effect - sorbents, interleukins and immunocorrectors providing for risk minimization is found out.

By means of the developed software several numeric experiments were carried out with the purpose of study of sorbent effect on the pathologic change risk reduction. The results are shown on figure 1. Curve 1 on figure 1a corresponds to the minimal risk optimum control task solution under two control effects - interleukin and immunocorrector, the curve 2 corresponds to optimum control task solution under three control effects (sorbent, interleukin, immunocor-rector). On figure 1b you can see corresponding to risk values found out in the course of solution of optimization tasks. On figure 1c corresponding control effects are shown. As you can see from the results, the use of sorbents in this case allows to reduce the absorbed dose and in the end the value of risk of pathologic changes.
The automated system of diet choice with the purpose of getting balanced ration

By means of software, that was elaborated, the following task are solved: 1) support of a given level of energy exchange under optimum fats-hydrocarbon ratio in organism, minimizing pathologic change risk; 2) automated ration calculation providing for given fats-hydrocarbons ratio in organism. By means of developed software optimum control task solution for purpose of achieving of given energy exchange level under optimum fats-hydrocarbons ratio in organism was solved. Results of solving of optimization task are presented in fig. 2.

Figure 2

The curves 1 on this figure correspond to energy exchange dynamics under constant rates of supply of organism with proteins, fats and hydrocarbons. The curves 2 correspond to the dynamics under the rates found out as a result of optimum control task solution. Results of modeling can be put out in form of table containing the data concerning necessary 24-hour supply of proteins, fats and hydrocarbons.
By means of developed programs an automated choice of ration, corresponding to calculated
dynamics of proteins, fats, hydrocarbons and given calorie amount under given intensity of
energy exchange level. The results of the calculations, containing menu, corresponding to
given requirements of rational diet, are put out on the screen.

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RETROSPECTIVE DOSIMETRY OF SOME POPULATIONS EXPOSED AFTER CHERNOBYL

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ABSTRACT. The problem of retrospective dosimetry is studied systematically from the point of view of practical application for emergency analysis and epidemiological follow up. Development and application of stochastic models for assessment of individual doses along with their uncertainties in case of the population of a radioactive release near zone is demonstrated on the example of Chernobyl evacuees. A problem of retrospective dosimetry of clean up workers is discussed with regard to practical demands of epidemiological studies. A complete liquidator dosimetry system is outlined and its implementation plan is discussed.

INTRODUCTION
In case of a communal radiological accident when large populations are involved, “radiobiological” detriment (compare with “psychological” and “economical”) may be measured by dose received by the people subjected to emergency. Clearly, when such accident occurs, in real life doses to large groups of public cannot be directly measured. Furthermore, at the early stage of an accident when radiological situation is not yet established, any modeling attempts may fail, determining thus a need for reevaluation of doses to public post factum. Therefore, in case of such large scale accident a need for retrospective dose reconstruction arises imperatively.

One of the clearest examples of such situation is Chernobyl accident. Doses to population of the 30-km zone were never directly measured, dosimetric assessment of impact on the contaminated territories does not consider the early phase when radionuclide composition and degree of contamination were unknown, dosimetric monitoring of clean up workers was incomplete and in many cases inadequate. At the same time the problems of evaluation of absolute risks of exposure (predicted yield of health effects) and, from the other hand – refinement of our knowledge about risks associated with radiation (epidemiological follow-up), requires an information about doses received by the population of concern.

The present paper addresses issues of reconstruction of individual doses of external exposure (which is commonly respected as leading factor for evacuees and liquidators) and describes the present status and perspectives of this work. Internal exposure (which is minor factor in case of the mentioned categories) and doses to thyroid are beyond the scope of this consideration.

INDIVIDUAL DOSIMETRY OF EVACUEES
Population of the 30-km zone was evacuated 2-20 days after the accident and, according to all previous estimations [1, 2] received, in general, not high doses. Obviously epidemiological follow-up of this cohort is not justified due to very low anticipated excess of radiation effects in this population. Nevertheless, there are two good reasons for evaluation of individual doses to evacuees. Although, on average, doses of evacuees were quite low, due to extreme heterogeneity of contamination and variation of behavior patterns, individual doses may vary in a very large range (more than three orders of magnitude). Hence, consideration of extreme
cases justifies efforts allocated to evaluation of individual doses. Another reason is of more
generic nature and deals with preparedness considerations. Chernobyl accident demonstrated
a lack of adequate tools for evaluation of doses of the population in a near zone of release.
Therefore, authorities need no have “ready to go” tools for operative evaluation of individual
doses of public and assessment of the uncertainties of these dose estimates.
In case of Chernobyl evacuees, the work on reconstruction of individual doses was based on
the results of direct dose rate measurements at time of accident and the information acquired
during wide scale public survey of evacuees, which involved more than 35,000 persons of all
ages in 1988-1989. Dose evaluation itself was conducted in two steps. First, individual doses
were calculated using simple deterministic model, which took into account individual
migration of the subjects, their stay in/out doors and dose rate fields averaged over certain
areas [2]. The second step involved sophisticated reevaluation of specific location (shielding)
factors, refinement of dose rate data and “state-of-the-art” interpolation of dose rates, and
application of stochastic dosimetric models [3, 4]. The output of such models was expressed
in individual dose distributions from which both likely dose value and uncertainty interval
may be derived. Doses were calculated for more than 25% of residents of Pripjat. It was
determined that in general exposure of evacuees agrees well with previous dose estimates [2],
analysis of uncertainties revealed that, as a rule, relative error (coefficient of variance) of such
assessment lays within 40-50%. The developed stochastic model allows account of many
individual parameters, which, at the end, have effect on both dose value and its uncertainty. In
general, this work demonstrated applicability of stochastic models to reconstruction of
individual doses to several tens thousands of exposed persons.

INDIVIDUAL DOSIMETRY OF LIQUIDATORS
Epidemiological relevance of the cohort of liquidators is very high. This category is an
attractive subject for risk assessment study due to many reasons. Liquidator cohort 95%
consists of male of age 20-50 at time of exposure, their exposure was, as a rule, chronic and
their relatively low doses are more relevant in context of evaluation of hazards of
occupational exposure. Obviously, all these factors favor strait forward application of the
outcomes of such study to risk assessment and setting standards in occupational radiation
protection. However, no sensible epidemiological study is conceivable without reliable
dosimetric information. Moreover, application of case-control design of a study and relatively
low statistical power in case of cohort design set enhanced requirements to the accuracy of
dosimetry, demanding, essentially, assessment of individual doses. Hence, there is a
pronounced need for a retrospective dosimetry system to be applied to the liquidator
population.
Retrospective dosimetry got significant development over the last decade. Among the most
remarkable developments one should mention practical implementation of EPR dosimetry
with tooth enamel, numerous tests of FISH biodosimetry in application to Chernobyl
liquidators, elaboration of expert dose assessment methods. However, most of the
retrospective dosimetry techniques are time consuming, expensive and are limited by a
sensitivity threshold. Therefore, application of retrospective dosimetry for risk assessment
studies requires development of certain approach depending on the epidemiological design of
the study and availability of resources.
The most generic scheme will include:
- verification of existing dosimetric arrays (results of dosimetric monitoring at time of
clean-up) and filtering reliable dose records;
- dosimetric screening of the studied cohort with universal and simple method;
- determination of doses of selected subjects (e.g. cases and controls) at the “state-of-the-art” level using high precision, yet more expensive protocols, and
- permanent quality assurance program aimed on validation of dose assessments and improvement of their quality.

Each of these stages was elaborated to certain degree over the last years.

Verification of dose records involves analysis of the statistical regularities of dose distributions and detection of possible extraneous admixtures (presumably falsified dose records). This work is performed on impersonified data sets and, clearly, may lead only to conclusion regarding the adequacy of the data set in general, not on individual basis [5]. Another possibility to verify existing dose records is selective application of reliable retrospective dosimetric techniques, which may be used as a reference. In this case uncertainties of some presumably inaccurate methods of dosimetric monitoring (like group-commitment method) may be assessed retrospectively.

Dosimetric screening tool should meet two basic requirements: (1) to be cheap and practical, and (2) to be applicable to all subjects (desirably even post mortem). Till recent time such tool was missing and none of the known methods of retrospective dosimetry matched these criteria. Therefore, the novel method of Soft Expert Assessment Dosimetry (SEAD) was developed by the International Dosimetric Group, operating under auspices of Ukraine-USA-France and CEC-Russia-Byelarus collaboration. This method is based on the analysis of information acquired from interviewing of liquidators and exploits regularities of dose distributions. The main advantage of this method is applicability to all subjects making it good for the screening of the cohort. At the moment SEAD is at the final stage of testing which involved cross-calibration with reliable dose assessments available for the same subjects.

Case-control study requires closer consideration of fewer subjects and in this regard high precision, yet more expensive techniques make use. Over the last few years robust and accurate protocol of EPR dosimetry was developed [6]; its quality was assured in a series of bilateral and international intercalibrations. However, at the present stage there is still certain deficiency associated with limited availability of tooth samples from the concerned subjects. In case of liquidators, this shortcoming is being mitigated now by collection of teeth from liquidators of 1986-1987 through the nationwide Tooth Acquisition Network (TAN). According to the established protocol, all teeth extracted from liquidators in course of normal dentistry are collected and forwarded to the Central Bioprobe Bank (CBB). The Bank serves for long term storage of tooth samples and provides material for selective retrospective EPR dosimetry. So far about 1,400 tooth samples from Chernobyl liquidators were collected and preserved in CBB. Although not very high percentage of liquidators was covered by this effort yet, two years of TAN-CBB operation had proven feasibility of this plan. As may be seen from discussion above, in the future TAN-CBB may establish a good material basis for application of high precision EPR dosimetry for assessment of individual doses for interesting subjects; possibility to apply EPR dosimetry post mortem only adds to a value to this approach.

Another method, which is potentially good for determination of individual doses long time after exposure is FISH biodosimetry. However, high sensitivity threshold (ca.250 mSv - higher than doses of the majority of liquidators), costly reagents and heavy labor intensity of FISH diminish its attractiveness with regard to application in Chernobyl follow up. Most likely, FISH may be used rather for early diagnostics and bioindication of such diseases as leukemia, than for individual retrospective dosimetry.

An inevitable component of liquidator dosimetry system is quality assurance program (QAP). None of the sources of dosimetric information may be considered as a priori accurate and
confident. Therefore, dose estimates should undergo tests called to prove adequacy of the applied protocols. At the moment liquidator related QAP is expressed in multi-method cross-validation when results of EPR, FISH, SEAD, analytical dose reconstruction (ADR), and official dose records are determined for the same subjects and are being compared. Subsequent QA will involve selective validation of the result provided by tested methods by application of independent methods.

CONCLUSIONS
Over the years after Chernobyl, a vast experience in field of practical retrospective dosimetry was acquired and summarized. The main concern in this research was related to development of approaches and techniques for assessment of individual doses for large groups of population and liquidators exposed to Chernobyl radiation. This task also included assessment of uncertainties of dose estimates. In general, post-Chernobyl decade was manifested by remarkable progress in approaches and techniques of retrospective dosimetry, allowing to derive more accurate and personified dose assessments for large groups of population than ever before. Application of “state-of-the-art” stochastic models to evacuee population allowed calculation of dose and evaluation of uncertainty individually to each interrogated evacuee. This work has both methodological and applied value. The need for reconstruction of doses to liquidators is determined by demands of epidemiological follow up. Liquidator dosimetry system comprises various approaches applicable for verification of existing dose values, screening of studied cohorts and high precision dose reconstruction for selected subjects. Although separate components of this system have been elaborated, the complete dosimetry system still awaits for its implementation.

REFERENCES
**RISK OF LONG DISTANCE TRANSPORT (FRACTURE / CORROSION STATISTICS IN GAS INDUSTRY 1980 – 1999)**

V. Polyakov, Pedagogue College

**ABSTRACT**

Pipeline long distance gas transport is not a safe way of energy transmission because there exist (scale), distance, thickness, corrosion and hydrogenation effects [1]. The risk R concept may be used to explain this conclusion

\[ R = F \cdot C \]

where \( F \) - accident frequency, \( C \) - accident consequences. The consequences of pipeline catastrophe are given in [2 - 20].

**KEYWORDS**

Stress corrosion cracking SCC, crack rate \( V \), yield stress \( \sigma_0 \), Young modulus \( E \), fatigue limit \( \sigma_f \), threshold stress \( \sigma_{th} \), stress intensity factor \( K \).

**IN TRANSPORT GAS/OIL PIPELINES CRACKS CANNOT MOVE AT STATIC LOADS**

Transgranular SCC in near neutral pH environment in oil/gas pipelines has been studied by testing full-scale pipes in soil media. Three pipes made of Grade 359 (X52) and Grade 414 (X60) steels have been used [21]. Sixteen cracks were prepared on the external surface of each pipe and crack growth was monitored and studied as a function of the pressure level and pressure fluctuation, the latter being described by the minimum to maximum stress ratio \( R \) and the loading rate.

Crack growth rate has been found to be affected by both the pressure level and the rate of pressure fluctuation. For the Grade 414 pipe, reducing pressure fluctuation by increasing \( R \) from 0.6 to more than 0.97 reduced crack growth rates to below \( 5 \times 10^{-9} \) mm/s, the detection limit of the crack depth measurement system used. Similar effects of pressure were also observed for the Grade 359 pipe.

For a crack with limited plastic deformation at its tip, the crack tip opening is related to stress and stress variation by

\[ \frac{\partial \delta}{\partial t} = \frac{2 \cdot \alpha \cdot K^2}{E \cdot \sigma_0} \]

(2), as can be derived from

\[ \delta = \frac{\alpha \cdot K^2}{E \cdot \sigma_0} \]

(3) Rice and Sorensen, 1978.

Where \( \delta \) - crack opening rate, \( \alpha \) - material constant.

It can be seen from this relation that the dynamic straining at the tip of a given crack is controlled by both stress level and the rate of stress increase in case of stress fluctuation. The use of J-integral for high plasticity conditions makes it difficult to separate the relative contribution of stress level and stress fluctuation, although it remains true that \( \delta \) approaches zero when the rate of stress changes approaches zero.
Twelve countries sponsored the work [21] of Revie W. et al. On the basis of these data, in North America specialists have concluded that fracture time of transmission gas pipelines depends mainly on pressure fluctuation not on pressure level.

Evidently the Americans are wrong for, several reasons. First, Revie's conclusions and formulae (2), (3) are in conflict with the Coffin law [22]

\[ \Delta e N^m = \text{const}, \]

where \( \Delta e \) - cycle deformation, \( N \) - cycle number before fracture, \( m \) - constant. Using Coffin type dependence and experimental data, the authors obtained that fatigue fracture occurred after plasticity reduction to very small levels or to zero. There is no fatigue strength in brittle gas pipes [23, 24].

Second, they used only clay type soil and NS4 experimental composition. Comparatively small diameter pipes (500 and 600 mm) were used.

The third reason. Test on aged pipes can estimate only hydrogen trapped in metal structure. But diffusion hydrogen damages pipe steel structure, even for smooth surfaces. Many works [4 - 39] support the conclusion.

**SCC MODELS OF GAS TRANSPORT PIPELINES**

GASPROM-VNIIGAS approaches concerning fracture accidents of transport pipelines have recently been presented by Antonov V., et al [27, 28, 35] in soil imitating media fracture could not occur at any cathodic potentials during mechanical deformation. They have found fracture of pipe steels at free corrosion and anodic potentials/ So the authors explain pipe fracture using anodic dissolution model [28].

One could agree with the authors [28] on the importance of corrosion activity of soils. However they use the concept of static fatigue as fracture model for transport gas pipelines. Strictly speaking a crack cannot propagate at static loads without external mechanical driving forces.

Sergeeva [28] suggested the existence of hydrogen fields in gas fractured pipelines [4 - 19], i.e. cathodic corrosion damages. However in sulfate reducing bacteria solutions Sergeeva has not discovered any cathodic corrosion damages besides local types of anodic damages [26].

Carbonate stress corrosion cracking. Parkins R. (England) was a grandfather of so-called carbonate stress corrosion cracking phenomenon. Dr. Fessler (USA) was a father of this phenomenon and studied it for transmission pipelines in America in the 60's. Gutman and Abdullin (Israel-Russia) have studied many practical cases of transmission pipelines carbonate SCC in 70-90's and organised special International Symposium, concerning this type of fracture [29 - 31]. This phenomenon may be presented as follows. During cathodic protection of buried pipes in aerated neutral soils we have

\[ 0_2 + H_2O + 4e \rightarrow 4OH^- \]  \[ 2H_2O + 2e \rightarrow H_2 + 2OH^- \]

At high pH values

\[ CO_2 + NaOH \rightarrow NaHCO_3 + H_2O \]  \[ NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O \]

That is why fracture in carbonate solution was named carbonate stress corrosion cracking Abdullin and Gareev gave an erroneous formula for so called carbonate stress corrosion cracking

\[ V = \frac{A \cdot C \cdot F(T)}{t - B}, \]

where A, B, C - constants, F(T) - is a temperature function, t-time before fracture.
However, $V$ cannot be reciprocal to $t$, because $V$ increases with the increase of crack length, and this rule is correct in most cases [33].

Gas transport pipelines operate at constant pressure $p$. So a classical expression

$$K \approx p \cdot L \quad (10)$$

shows that it's impossible to stop crack propagation without fracture. In addition the formula (9) does not take into account mechanical stresses and cannot be used [10].

Beavers J. and Harle B. have indicated that at least two mechanisms of cracking are responsible for the SCC observed in operating natural gas pipelines:

- high pH SCC reported by Parkins, Fessier in the 1960's and later by Gutman and Abdullin,
- near neutral pH SCC of underground pipelines.

The most plausible mechanism for crack propagation in near neutral-pH environment is a hydrogen related mechanism [34];

the most likely source of hydrogen in near-neutral pH SCC is carbonic acid, formed by the dissolution of carbon dioxide in groundwater

$$\text{CO}_2 + \text{H}_2\text{O} \longrightarrow \text{H}_2\text{CO}_3 \text{ (sol)} \quad (8)$$

The carbonic acid can further react with water to produce a hydronium ion and a bicarbonate ion

$$\text{H}_2\text{CO}_3 \text{ (sol)} + \text{H}_2\text{O} = \text{H}_3\text{O}^+ + \text{HCO}_3^- \quad (9)$$

The hydronium ion is reduced to generate hydrogen at the metal surface.

Beavers-Harle have used the concept of threshold stress and for gas transport pipes obtained $\sigma_{th}$ between 60% and 70% of specified minimum yield strength SMYS.

Specialists often use $\sigma_{th}$ method (standard NACE National Association of Corrosion Engineers USA) investigating stress corrosion cracking in H$_2$S and H-containing media. These tests are only comparative [13]. For quantitative estimations gravimetric and electrochemical polarisation tests have been recommended as well. Then real components and for samples with cracks and notches are tested.

In [4-19] criticism has been presented that carbonate stress corrosion cracking phenomenon occurs in transmission pipelines. No carbonate-containing corrosion products have been discovered in the pipes. Hydrogen fields in surface layers have been estimated to the main cause for transmission pipeline fractures. The following reasons can initiate hydrogenation:

- high cathodic potentials,
- anodic hydrogenation.

**SCALE (SIZE) EFFECT**

The characteristics of the two forms of gas transport pipelines cracking are discussed. The authors have found that SCC occurs less frequently on heavy wall pipe where hoop stresses are lower. The result is in conflict with size effect according to which the effects of fracture in large and small diameter pipes differ considerably i.e. fracture accidents involving smaller diameter pipes are considered to be less dangerous and the risk of obtaining a brittle thin-wall material (0.188 -in. wall thickness or less) is much lower than the risk of obtaining a brittle heavy-wall materials (0.375-in. W.T. and larger) [36, 37, 38].

**DISTANCE EFFECT AND ECONOMY**

A major participant in the international gas business, Algeria has been playing a leading role in gas exports over the past 30 years. In 1996, the country exported 41 bcm, 21 bcm of which were delivered by pipelines. Projects for 2010 call for nearly doubling these volumes. To provide growing share of supply, two major projects have recently started up: expansion of the Trans-Mediterranean line to Italy and the Maghreb-Europipe pipeline linking Algeria to
Spain and Portugal via Morocco. The economics of a long-distance (2000-2500 km), large diameter (40-48 in.) gas transmission line depends on a minimum pipeline throughput of 10-15 bcmy (billion cubic meters per year). A pipeline bringing gas from the fields in Southern Algeria to southern Europe and having a capacity of 10-15 bcmy would require today an investment of $3-4 billions. Building of pipeline land section costs $1.5-2.5 million/km and $2.5-3.5 million/km for an offshore section. Transportation costs are critically important because they tend to represent an important element of the cost of gas supply for long-distance gas pipelines. They include technical costs and transit fees. When an international gas pipeline project must cross more than one country on its way to final consumers, a transit fee is paid to the third countries crossed by the pipeline. In the case of Transmed and Maghreb-Europe pipelines, only one transit country is crossed by each line [39].

Concerning Siberia-Europe and Siberia-Turkey. There exist more problems pipelines. There are several transit countries and distances from Siberia to Europe and Turkey are much longer. Long distance gas pipeline transport from Siberia to the West is profitable only using large diameter pipelines, mainly 1420 mm. Russia possesses an amazing gas resource base. However, official figures overstate the recovery factor for gas in place and appear to systematically overestimate volumes of recoverable gas in undiscoverable fields. Of 212 tcm of initial recoverable resources in Russia, approximately 33 tcm of remaining recoverable gas is concentrated in 16 fields that constitute the nation’s key gas resources. It is this gas which will support most of the volumes supplied over the next 20 years. These key resources are distributed very unequally with respect to the technology and investment required to bring the gas to the market. The cheapest sources will be Urengoy and Yamburg fields. These are followed by Zapolyarnoye field and the Urengoy satellites. Production and transportation of gas from Yamal peninsula, the Kara and Barents seas will cost many times the current average cost of gas production in Russia. Only a few offshore fields will contribute to supply by 2015. All of approximately 39 tcm of offshore undiscovered gas is irrelevant to Russia supply through 2015. These resources include those distributed in the Laptev, East Siberian and Bering seas, where cost of production and transportation will be astronomical and unquestionably place these volumes (which are probably exaggerated anyway) well beyond the pale of supply over the next 20 years.

**RECENT RESULTS CONCERNING FATIGUE CRACK BEHAVIOR**

Typical dependencies crack L vs a number of cracks n have been obtained in [7, 18]. L was inversely proportional to n. Analogues laws may be obtained for short cracks [1]. Accumulation of small damages (short cracks, pores etc) can be the main cause of pipe ageing and respectively of a decrease of mechanical properties $\sigma_{\text{th}}, K_{\text{th}}, K_{\text{lc}}$.

Experimental facts have recently suggested this scheme: after 27 years of operation transport gas pipelines with diameter 720 and 820 mm, made of low-alloyed steel 17Å 1C and carbon steel 20K, the transition brittle-plastic temperature shifted to a positive temperature range and fracture toughness decreased. Other mechanical characteristics of aged pipes $K_{\text{th}}, \sigma_{\text{th}}, K_{\text{lc}}$ etc decreased as well.

Quasi-elastic analysis has been used. Stress intensity coefficients varied in the range 28-64 MPa$\sqrt{m}$. The data obtained surprised specialists 1-fatigue crack growth rates in low-alloyed steels were in 1.6-2 times lower than in carbon steels, 2-fracture toughness in low-alloyed steel was 2-4 times higher than toughness in carbon steels [40].
DISCUSSION
Ulmasvaj F. has recently concluded that catastrophes of gas pipelines occurred between Earth blocks [41]. The damaged zones ranged from several meters to dozens of kilometres. The picture of fatigue short cracks was presented in [7].
In Norway 1997 the author presented statistics in transport gas pipelines in the former USSR for the last 18 years. Statistics show that there were 90 - 100 accidents involving 1420 mm pipes with an average life-span of 6 years. Pipes of 1020 mm harbored more than 200 accidents with a life - span 13,7 years while pipes of 1220 mm had 150 accidents with a pipe life-span 12,6 years [ 4 ] . In 1980 - 1999 there occurred nearly 600 catastrophic accidents of large diameter gas pipelines:
- about 100 accidents of diameter 1420 mm,
- 180-200 catastrophes with diameter 1220 mm,
- about 300 accidents of diameter 1020 mm.
Many thousands of short corrosion cracks present in aged gas transport pipelines. The picture of short SCC cracks was presented in [7]. Kosanda, D. [42] showed that short cracks rate at the beginning of the start is high then V decreases sharply. Calculation methods for fracture time of pipes with short SCC cracks are absent at the moment. However Kocanda attempted to do it.
Critical crack estimation methods will be discussed. In the condition of constant intensive hidrigenation it is necessary to stop operation of large diameter gas pipelines because hydrogenation can decrease critical crack length to very small levels . SCC models for pipes will be presented. Particularly, SCC at high pH and SCC in hear neutral pH.

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