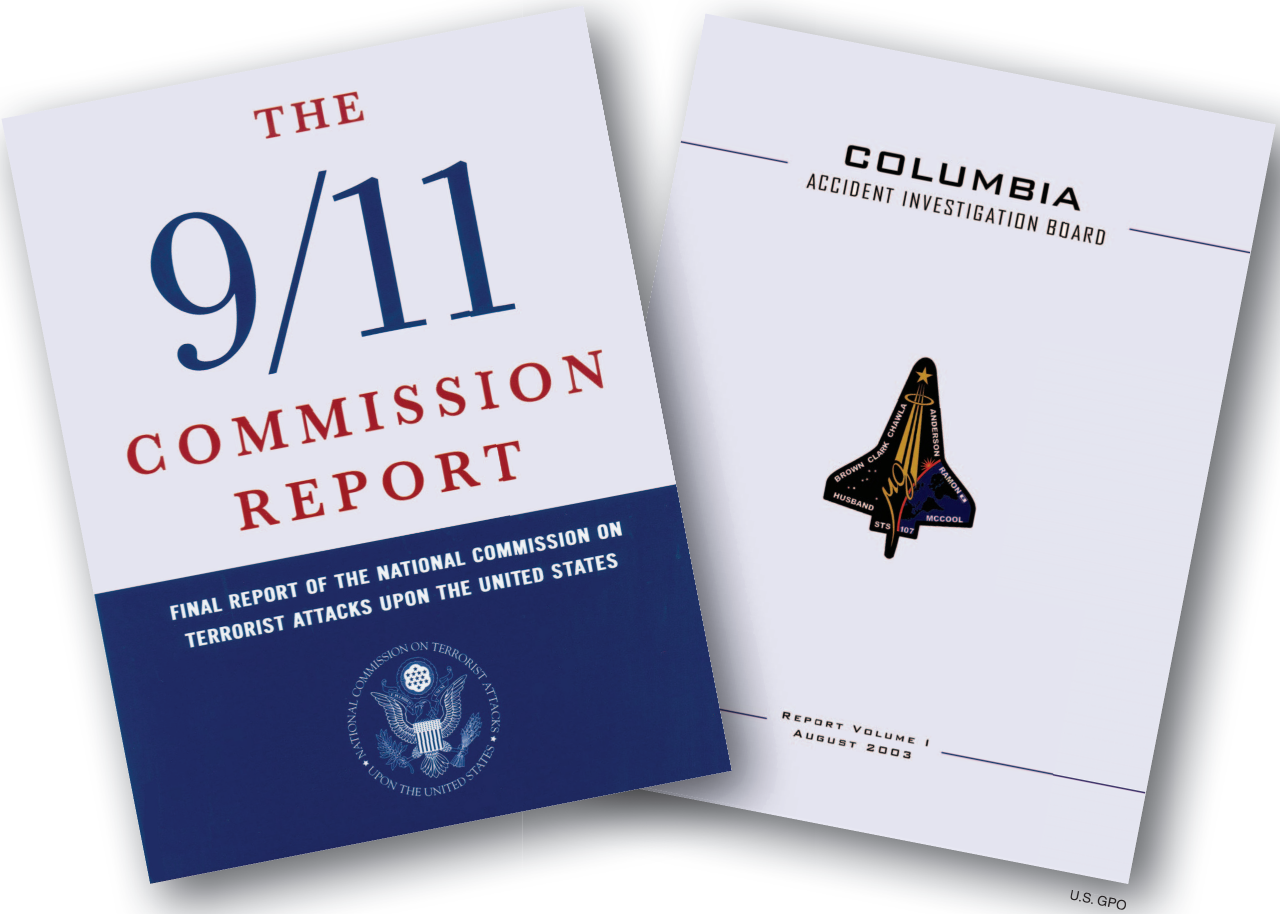


U.S. GPO

# Learning from Disasters

## Competing Perspectives on Tragedy

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After a major disaster, questions like "How could this happen?" and "Could we have prevented this?" arise. One way governments and organizations respond to such questions is by forming investigative committees.

Governments and decision-makers learn from these investigations. The safety of airline travel, of nuclear power plants, and fire safety have all improved because of detailed analyses of accidents and near-accidents.

But there is also concern about *how much* organizations learn from these analyses. There is a suspicion that they need to learn more. Continuously recurring recommendations of investigations committees, in various areas, are that professionals should share their information (9/11-Commission [17]), that information should not be ignored by decision-makers (e.g., Roger Commission, Challenger [22]), and that cooperation between agencies should be improved (e.g., Independent Levee Investigation Team, New Orleans Flood [13]). In The Netherlands, investigation committees analyzed three fatal fires (Enschede 2000, 23 casualties, Volendam 2001, 14 casualties, Schiphol 2005, 11 casualties). There is one observation that they all share: the same flaws reoccur. Governments should know what they have to do because there are clear procedures, but it seems they hardly learn to deal with organizational fragmentation [4], [5], [19].

Why do the same problems reoccur? Is this unwillingness or ignorance of decision-makers? Both might be the case. But there is an alternative explanation: possibly the way investigation committees analyze organizational processes and fragmented contexts is not optimal. Investigation committees often face a complex chain of events and have to construct these into an understandable report. The way committees do so might impact how much people learn (and don't learn) from the report. In other words: *Are the perceived limited learning capabilities of decision-makers in fragmented organizational settings due to the investigation committees and their reports? And if so, how could this limited learning from investigation reports be explained?*

The heart of this essay is an examination of four investigation reports, two from Holland and two from the United States. Based on these reports, we will present a simple typology of approaches by investigators for interpreting the facts that they find. From the perspective of decision-makers that make potentially disastrous decisions, we will explain the strengths and weaknesses of these approaches for learning. From the perspective of the investigators, we will explain the logic of these approaches. The difference between the two perspectives explains why it is often difficult for decision-makers to learn from investigation reports.

## Safety and Disasters: A Decision-Maker's Perspective

Disasters can be seen as failures of socio-technical systems [8], [20], [24]. Decision-makers are part of the socio-technical system that failed. Decision-makers in an organization in which safety is an important value should make a risk assessment before they decide. Ideally, this risk assessment would consider all imaginable risks. However, it is unlikely that this risk assessment will be the only basis of a decision in any socio-technical system. Other values, such as health, environment, and efficiency, will be advocated for from within and from outside the system. Tradeoffs between risk and efficiencies are well-described in the literature [10], [11], [17], [21]. Decision-makers have to make such tradeoffs, balancing a variety of different values. A good decision-maker is aware of these often-competing values and tries to respect all values in his tradeoffs [1]. We therefore assume that an ideal decision-maker both makes a risk assessment, and also respects the outcome of such an assessment in a tradeoff against other important values.

However, this is far from simple. A proper risk assessment implies solid information on the potential damage of an accident and the probability that an event will occur. However, in highly complex environments it is difficult for individuals to know all the risks and their probabilities. Indeed, according to Douglas and Wildavsky [6], no one person can know more than a fraction of the dangers that exist. It is also difficult to recognize the "real" dangers until afterward. Therefore, Douglas and Wildavesky suggest that we select dangers without knowing everything about them. They found that "questions about acceptable levels of risk can never be answered just by explaining how nature and technology interact" [6].

Safety standards are often codified in regulations. However, the functionality of regulation decreases as the system to be regulated becomes more complex [14]. If a system is complex, decentralized professional knowledge about the system, professional norms, and professional judgments all become more important. Brian Wynne describes many technologies in complex socio-technical systems as "unruly," which means that engineering decisions are made in largely un-structured situations that are not well covered by rules [29]. This regularly leads to conflicts between rules and actual engineering conduct. A decision-maker might find him or herself amid conflicts between regulation and professional judgment.

A lack of hard facts about safety complicates the task of defending safety in terms of tradeoffs. It is often possible to make costs and time explicit. Safety as a value

**Table I**
**Safety—The Decision-Maker's World**

| | The Decision-Maker |
|---|---|
| Expectation from environment | "Everything under control" |
| Position | Part of the socio-technical system |
| Main orientation | Forwards: what must happen? |
| Related main problem | Balancing risks; risk selection |
| Problem handling | Implicit |

remains more implicit. As Weick defines it, safety is a "dynamic non-event." He states that safety is "an ongoing condition in which problems are momentarily under control due to compensating changes in components.… [they are] invisible in the sense that reliable outcomes are constant, which means there is nothing to pay attention to" [28]. This invisibility has been nicely illustrated in a study by Toft and Reynolds, in which a mining financier states "In mining you are always saying there is a risk the roof will fall in and you be left without a mine at all. But you don't expect it to actually happen" [25].

So from a decision-maker's perspective, safety is problematic. Because risk assessment will not lead to certainties about risks, just following regulations or professional judgments will not guarantee safety; and safety as a value is difficult to weigh against other values. This is why both risk analysis and tradeoffs are inevitably subject to non-scientific judgments of decision-makers. This judgment is by definition subject to human and organizational constraints [24].

Risk selection and risk taking often stay implicit, for at least two reasons. First, as pointed out before, these decisions are largely intuitive and therefore tacit. Second, risk selection is not a very popular story to tell to the public, for they will expect decision-makers to apply to the highest safety standards and to promise that "everything is under control". However, risk taking cannot fulfill that promise.

Table I illustrates the decision-maker's world, according to the notions outlined above.

With this perspective in mind, we will analyze four investigation reports about four accidents, two Dutch and two American.

## Two Dutch Disasters

On 27 October 2005, a fire in a detention center at Schiphol airport led to eleven deaths. Fifteen others were wounded. The Dutch Safety Board published an investigation report on September 21, 2006. The report found that several significant errors contributed to the disaster, including:

- The design of the detention center did not meet the requirements of security regulations;
- Coordination between the fire department and the operators of the detention center was insufficient, which resulted in the firefighters arriving late;
- A prisoner in a cell started the initial fire. He was rescued, but the cell door was left open causing the fire to spread. [18].

On July 2, 2006, the Probo Koala, a tank ship carrying gasoline and toxic waste, arrived in Amsterdam. The ship's destination was not clear at that moment. The waste was pumped over in Amsterdam, but the owner of the waste later requested it to be pumped back as he found that the costs of offloading in Amsterdam were too high. He got permission for the vessel to leave the port of Amsterdam. Eventually the waste was dumped near the coast of Cote d'Ivoire, resulting in ten deaths and thousands of people falling ill. A Dutch investigation committee—the Hulshof Commission—found that:

- permission to pump back the waste was in conflict with regulations;
- officials of Amsterdam's environmental department were unaware of this;
- officials failed to report this to the Amsterdam port authority, which could have ordered the waste to be offloaded [3].

These two cases show important similarities. Both commissions made a thorough analysis of the facts. Those facts show a chain of events rather than a single event. Both cases illustrate the problem of "many hands" and that persons and organizations did not cooperate sufficiently. In addition, regulations were violated in both cases.

A major difference between the reports appears when the commissions *interpret* the facts they found. The conclusions and recommendations differ strikingly. The Safety Board concluded (authors' translation):

> "The Dutch Safety Board considers it justified to conclude that there would have been fewer victims if the organizations concerned had paid more attention to fire security. …The security aid of the DJI [the owner of the detention center] should have been better designed, prepared and trained, including the cooperation and coordination with the fire department. The … detention centre should have been built… according to the 'Bouwbesluit' [the building regulations]" [19].

The judgment of the Hulshof Committee on the Probo Koala is milder (authors' translation):

> "Were the operating procedures of the Amsterdam officials and the cooperation with outside organizations sufficient? (…) The answer is a nuanced 'no': they were not sufficient for the conditions, which were extraordinary. Probably they were sufficient for ordinary daily jobs in ordinary conditions. The commission therefore would have been unable to answer the question who was to blame, had it been asked to do so" [3].

We find two important differences between the two reports regarding these interpretations of the facts:

1) The Safety Board stresses the *causal relationships* between the events and the victims. The Board asked themselves if there might have been fewer victims if the organizations had cooperated better and if they had complied with regulations. This provides answers to the question of what decisions led to the disaster, and what alternative decisions would have prevented it. On the other hand, the Hulshof Commission stresses the *context* of the events. The Commission asked itself why regulations were violated, and pointed out the peculiarity of the case, the complexity of the relevant regulations, the multiplicity of organizations involved, and the tradeoffs made by the officials. By doing this, the commission answers the question of what made the disastrous decisions understandable. A contextual approach addresses Vaughan's concerns that retrospective analysis of bad organizational outcomes naturally tends to focus attention selectively on the road not taken that might have altered the outcome [27].
2) The second difference is related. The Safety Board focuses solely on the case under study. We call this a *casuistic* approach. It provides us an answer to the question of what decisions led to the disaster *in this particular case*. The Hulshof Commission compares the specific case with other cases in which the same people were involved. This *comparative* approach answers the question of to what extent would the decisions that proved to be fatal have had the same effects in comparable situations. To some extent, this approach is inherent to a contextual approach: paying attention to the context often leads to a comparison with similar cases. It shows that one type of behavior could be adequate in many cases, but could be harmful in others, and vice versa. An illustration of this can be found in an issue surrounding the fire detection system at the Schiphol detention center. A delay was built into this system, which led to a delay in the arrival of the firefighters. A casuistic investigation would lead to a conclusion that the delay in the system was dysfunctional. A comparative conclusion would weigh the delay of the firefighters against the situation that would arise if the delay had not been built in: an abundance of false alarms. A comparative approach addresses Perrow's concern that inquiries are usually "left-censored" in that they examine only failures and not systems with the same characteristics that did not fail [20].

In summary, we distinguish four fact interpretations by investigation committees, of which two pairs potentially compete:

1) A causal interpretation: What decisions led to the disaster?
2) A contextual interpretation: With what context was the decision-maker faced, and did this context make the particular decisions that proved to be fatal understandable?
3) A casuistic interpretation: What decisions led to the disaster in this particular case?
4) A comparative approach: To what extent would the decisions that proved to be fatal have the same effects in comparable situations?

Fig. 1 shows a comparison of the two Dutch cases on this typology.

## Two U.S. Disasters: 9/11 and the Columbia Accident

In February 2001, the Space Shuttle Columbia broke up while re-entering the atmosphere. In August 2003, the Columbia Accident Investigation Board published their report, finding that "the physical cause of the loss of Columbia and its crew was a breach in the Thermal Protection System on the leading edge of the left wing, caused by a piece of insulating foam which separated from the left bipod ramp section of the External Tank at 81.7 seconds after launch" [2, p. 9]. During re-entry this breach allowed superheated air to penetrate through the leading edge insulation, eventually resulting in a "weakening of the structure until increasing aerodynamic forces caused loss of control, failure of the wing, and break up of the Orbiter" (p. 9). The Board refused to interpret the accident as an anomalous, random

| | Causal | Contextual |
|---|---|---|
| Casuistic | Schiphol Fire | |
| Comparative | | Probo Koala |

Fig. 1. Comparison of two Dutch cases.

event, and broadened its mandate to include historical and organizational issues. Based on a thorough study, they found a wide variety of organizational causes, including:

- Failure to classify loss of foam (known from previous flights) as an "in-flight anomaly" [2, p. 125]. Instead loss of foam was classified as "in-family" resulting in a lower level of concern at NASA [2, pp. 168–169];
- The repeated denial of requests from a project team studying potential damage of the Columbia for on-orbit-imagery of the left wing, formulated by the Board as "missed opportunities" [2, pp. 145–170];
- A failure of that project team to disseminate information to all system and technology experts who could be consulted [2, p. 169];
- The application of an inappropriate mathematical tool to simulate the damage, as an alternative to on-orbit imagery [2, p. 168].

On September 11, 2001, two airliners plowed into the two towers of the World Trade Center in New York, a third airliner hit the Pentagon, and a fourth crashed in Pennsylvania. Almost 3000 people died. In this case, the cause of the disasters was clear. There was not a series of "mistakes," but a purposeful attack by terrorists. However, many asked themselves whether this attack should have come as a surprise. In 2004, the National Commission on Terrorist Attacks Upon the United States (known as the "9/11 Commission") published a comprehensive report about the functioning of the Intelligence Community (ICo). The commission's findings included:

- Missed operational opportunities, including not sharing information, not discovering false statements and manipulated passports, not watch-listing and trailing future hijackers, and not informing the FBI about one future hijacker's U.S. visa or his companion's travel to the United States [17, pp. 8–9, 269–277];
- A lack of imaginative power to judge the gravity of the threat, resulting in a lack of serious options for the Presidency to counter it [17, p. 9, pp. 339–348, 350–352];
- The inability of action officers to draw on all available knowledge about al Qaeda in the government, because of dysfunctional specialization [17, p. 11, pp. 353–360].

Here again, both cases deal with an incident in a socio-technical environment. They both show a chain of events, and a problem for which many people and organizations bear some responsibility. Although, apparently, no regulation was explicitly violated, the events showed a severe departure from a safety culture we expect from the organizations concerned.

One of the main findings of the Columbia Accident Investigation Board is that the request for imagery-on-orbit was not granted. Had it been granted, the damage on the left wing would probably have been detected and a repair or rescue action would have been taken. In Ch. 6, the Board focuses on all "missed opportunities" to discover the extent of the damage on the left wing. In the following chapters the Board describes the broader context of these missed opportunities, i.e., the organization of NASA, its culture and the key players of NASA between the two space shuttle tragedies (i.e., Challenger and Columbia). By doing so, the Board pays attention to both causes and contexts. The Board also compares the Columbia accident with the launch of the ill-fated Challenger in 1986. They found striking similarities between the two accidents, like a long successful period beforehand, a can-do culture at NASA and the impact of policy decisions [2, ch. 8].

The answers to the causal and casuistic questions are clear. The repeated denials to requests for imagery-on-orbit were decisions that led to the disaster.

The contextual questions and comparative questions are harder to answer. Broader organizational, political, and cultural issues are relevant for understanding the context of the disaster, as are the broader similarities between NASA before the Challenger and the Columbia. However, these broad observations help little to understand the particular tradeoffs facing the decision-makers that denied the requests. These tradeoffs would be more understandable given more information about the specific complexities the decision-makers faced as the context of their denials. With additional context, attention could be paid to the process of organizing "challenging" at NASA.

Engineers work on subprojects, critically watched over by a competing team of engineers that traces weaknesses in design and construction. The competing teams will discuss these weaknesses until the debate is closed. Such checks and balances imply a continuous deliberation between engineers. Therefore, in hindsight, any weakness that leads to failure will always have been signaled by some engineer. The existence of such engineers is, in fact, an indication of the strength of the organization. It also means that an organization like NASA generates a cacophony of warnings, which makes it hard for decision-makers to select a particular single warning that will eventually prove vital (see Douglas and Wildavsky [6]). Considering this context would also help us understand denials in comparable cases. Many requests have been denied without a disastrous outcome. An analysis of the way these requests have been denied could clarify the way decision-makers successfully take risks in their tradeoffs between safety and other values.

We conclude that the Board considered all four approaches, but it used a very high level of abstraction for contextual and comparative analysis. This leaves questions unanswered about the particular tradeoffs decision-makers made for their fatal decisions. Eventually, this leaves us with the main observation that vital warnings were denied and the recommendation to heed these warnings. Both in a causal and in a casuistic approach, any denials of such warnings are "missed opportunities."

The 9/11 Commission report reads as a narrative about intelligence in the period between the first World Trade Center Bombing in 1993 and the September 11, 2001, attacks. A striking finding is that many pieces of information on possible terrorist attacks were known to the security services. The commission determined several specific situations in which vital information was not shared [17, pp. 355, 356]. The commission also found many accurate early warnings (e.g., [17, p. 341]). The commission found a shortage of information for the Presidency to prepare the public for a fight against terrorism [17, pp. 339–348]. It illustrated that "the volume of warnings of Al Qaeda threats (…) was in the tens of thousands (…). Yet the possibility was imaginable, and imagined" [17, p. 345]. Action was not committed, even when "the system was blinking red" [17, ch. 8]. Following these observations, the commission looks for institutional barriers to sharing information and committing those actions [17, pp. 344–348, 357–360]. The central recommendation is that, to increase sharing of information, the intelligence community and participants in counterterrorism need to be unified [17, pp. 399, 400].

## Disasters can be seen as failures of socio-technical systems.

These observations clarify the causes of the lack of action. The question of what decisions led to the disaster (in this particular case) were answered clearly: information was available, but not shared, and information that was available didn't result in action. Apart from these findings, an impressive collection of contextual elements is described. The report explains that proper tradeoffs were not made because of competing priorities, institutional uncertainties, and "burdens of the past." The observations include:

- A misunderstanding and misapplication of procedures, leading to the false impression at the FBI that specific information couldn't be shared with agents working on criminal investigations [17, pp. 79, 271];
- An abundance of diplomatic problems during the first months of the new Bush administration [17, pp. 203, 204];
- Uncertainty as to whether a specific (then potential) terrorist could be imprisoned if arrested [17, p. 273];
- A lack of incentive for the CIA to carry out covert action, because this covert action, promoted by the White House, led to trouble in the past [17, p. 351].

We observe that both causes and contexts have found their way into the 9/11 report. The recommendations are mainly to facilitate information sharing by lowering institutional barriers. The recommendation is based on both the causal observations (i.e., information has not been shared and actions have not been committed based on vital information) and the contextual observation that institutional uncertainties have hardened information sharing.

The comparative question is more difficult to answer with the report because the commission, for good reasons, took much effort in tracking all information that would be vital for preventing the attacks. The implicit suggestion is that not sharing this information has been problematic. This, in hindsight, is the case. Yet for other cases, decisions not to share information could be wise and professional. Possible reasons for this:

- A considerable risk of sharing all information is information overload.
- Sharing information can be dangerous; sharing incomplete information could lead to harmfully wrong interpretations.
- Information may lose its meaning through sharing. For example: if the receiver of information uses information about an unimportant suspect too early, important suspects could be warned.

The risk of not addressing such reasons in the conclusion of the report is that they stay relevant after the recommendations are implemented. Good reasons for not sharing information still exist despite implementation of the recommendation.

We conclude that the commission adopted three of the four approaches. It produced a rich narrative including causes and contexts of fatal decisions. It reveals the tradeoffs behind these decisions, but doesn't make these particular decisions understandable by comparing them with similar decisions in comparable cases that worked out better.

Classifying both investigations as causal and/or casuistic does not respect the considerable amount of work these investigators have done. Both commissions explicitly pay attention to the context of the accidents. The Board distinguishes historical, cultural, and organizational factors and describes the political pressure on NASA from the very start of the shuttle projects, subsequent years of resource constraints, and schedule pressures. The Board also compares the Columbia accident with the launch of the ill-fated Challenger in 1986. The 9/11 Commission paid attention to problems of diplomacy with Arab allies, the intelligence before and after the Pearl Harbor attack, the first World Trade Center bombing, and the attack on the U.S. Cole.

Still some important "why" questions of a contextual approach—i.e., "Why was *particular* information not shared?" and "Why were *particular* requests for imagery-on-orbit refused?"—remain unanswered. These "why-questions" are important, because they address the tradeoffs decision-makers made in specific situations that appeared to be vital. Addressing these tradeoffs makes a report recognizable for decision-makers. The broader historical, cultural, political, and organizational issues raised by the Board and the Commission address the context of these tradeoffs—and are therefore a meta-context of the fatal decisions. They could facilitate answering the question of whether the tradeoffs made were reasonable. But without the "why-questions" posed above, this meta-context will provide little help to make sense of the fatal decisions directly. We therefore suggest that both reports have a tendency to a casuistic interpretation of facts.

## Learning Potentials of Reports: Strengths and Weaknesses of Approaches

Obvious similarities in cases do not necessarily result in similarities in the way investigators interpret their findings. We have made a typology of approaches to these interpretations. However, how does this typology relate to learning by the decision-makers concerned? Each approach has potential strengths and weaknesses for decision-makers' learning.

A causal-casuistic approach leads to clear reports. The chain of events becomes visible. It is also possible to compare actions with procedures and regulations and find deviations. This makes causal-casuistic investigations communicative: they show society what happened, how we prepared for such an accident, and where preparation procedures were violated. This could help identify reprehensible actions.

> Any weakness that leads to failure will always have been signaled by some engineer.

From a decision-maker's perspective, the analysis and recommendations from a causal-casuistic approach may be much less valuable. It is nice to find out what happened and where procedures and regulations were breached, but the why-question remains. For NASA: Why was the request for imagery-on-orbit denied? Was it risky for the crew? Would it have led to a delay? What consequences would such a delay have had? And for 9/11: Why did security services not share information *on particular events*? Was it the right moment to share the information? If such contextual questions are not answered, underlying management dilemmas are ignored. This means that the continuous process of conducting risk assessments and the tradeoffs between safety and other values are not recognized.

Neglecting this process may result in ineffective recommendations. The recommendations become a "scientist's fantasy" [15]. The sharing of all information by security services and the heeding of all warnings within NASA could lead to congested information channels, severely reducing the ability of these organizations to react.

It is doubtful whether decision-makers will act on unrealistic recommendations. As the accident fades in our memories, these decision-makers still face a continuous series of dilemmas that the investigators failed to recognize. The "event" nature of inquiries estranges it from the continuous process of organizational learning [7].

A contextual-comparative approach is much more acceptable to decision-makers. A report that shows underlying management dilemmas and provides information on the complexity of decisions makes sense to decision-makers. However, the "why-questions" could be dangerous. Acknowledging the difficult position of decision-makers could easily evolve into legitimization. Following a contextual-comparative report, it is relatively easy for decision-makers to hide behind complexity and extraordinary conditions. The report will not provide a clear basis for accusing those who truly acted irresponsibly. A far-reaching emphasis on context and comparable cases ultimately results in the conclusion that the accident was just "bad luck." The report reads like a story and nobody finds any reason to change the standard procedures. If a contextual-comparative approach produces a lack of obligations, that also is a threat to learning.

## Safety and Disasters: An Investigator's Perspective

Until now, we have observed that three of the four investigation reports showed at least tendencies to a causal and/or casuistic approach. We also theorized some strengths and weaknesses of the different approaches to learning. But what explains the approaches used by the committees? To answer this question, we will have to change from the decision-maker's perspective to the investigator's perspective.

Investigators are usually not part of the failed socio-technical system. They are asked to study the accident after the fact. Still, the context of this study makes the exact assignment ambiguous. Hutter studied public inquiries of railway accidents in Britain. She found that the primary role of an inquiry is to determine the cause of the accident. The most important purpose of the inquiry is to make recommendations to prevent the reoccurrence of the accident. However, she also observed that the rationale of these inquiries is to "anticipate, respond, and even appease public and political concerns" and make a "public statement that accidents are regarded very seriously" [12].

With these functions—finding the cause and appeasing public concerns—in mind, investigators will have to clear up a problem of many hands in a knowledge-intensive environment. Clarity is a main value here, because a clear explanation supports the public's understanding of what happened and what should happen to prevent reoccurrence.

A critical decision is setting the investigation's scope, which can have a major impact on its findings [25]. How far investigators should go in examining secondary causes of an accident is debated [8], [12]. Any choice in setting the scope involves the danger that the investigators may be accused of "investigative bias" (i.e., unjust weighing of factors of influence). Some criticize the political affiliation of committee members [12], [25], while others complain about the relevance of their technical knowledge [8], [15].

It is difficult to prevent such criticisms when studying complex socio-technical systems, because many problems in complex systems are ill-structured and hard to define. The committee is expected to define problems explicitly in a clearly written report. Since the reasons behind the causes of an accident can be seen from a multitude of perspectives, an investigation committee is likely to be criticized no matter what perspective they select [8].

In finding the cause of the accident and formulating recommendations, investigators face the problem of hindsight. The investigators already know that decisions proved to be disastrous. The people that made them did not know this beforehand. Turner criticized investigation committees for neglecting this issue: "Each report dealt with the problem that caused the disaster as it was later revealed and not as it presented itself to those involved beforehand" [26]. But even if a committee is aware of this problem, like the 9/11 Commission [17, p. 339], there is no well-known way of dealing with this extra knowledge in interpreting causes and writing recommendations.

> Investigators are usually not part of the failed socio-technical system.

A good investigator will find the technical and main organizational causes of the accident. Hindsight or not, those causes are clear and they are relatively easy to make explicit. A chunk of foam damaged the left wing of the Columbia, warnings were ignored, information about terrorists was not shared, regulations on building cell-complexes were violated. The context will always be contestable, because the problems decision-makers faced were ill-structured. Any investigation that has the task of appeasing concerns will have incentives to stress the causal and casuistic part of the report. The causal facts are not contestable, but contextual factors are. It could be a scientific message that accidents in complex socio-technical systems are "normal" [20], but that is not a message the public wants to hear.

Table II summarizes the investigator's world as depicted above.

**Table II**
**Safety—The Investigator's World**

| | The Investigator |
|---|---|
| Expectation | Clarity |
| Position | Outside the socio-technical system |
| Main orientation | Backwards: what happened? |
| Related main problem | Balancing expectations; factor selection |
| Problem handling | Explicit |

## Limited Learning

Is the perceived limited learning of decision-makers dealing with fragmented organizational settings due to investigation committees and their reports? If so, how can this limited learning be explained?

We actually cannot answer the first question, because we haven't made a thorough causal analysis of investigation reports and learning by decision-makers. We do suggest that investigation committee approaches adopted in their work may have major implications for this learning. Both the clarity of the cause of the disaster and the way investigation committees address the tradeoffs made by decision-makers are central issues in learning.

Decision-makers have to make tradeoffs between values, including safety. Weighing safety as a value is difficult because it is implicit. The decision-maker's dilemma of weighing safety is an intuitive process and—especially after an

**Table III**
**Safety—Two Worlds**

| | The Decision-Maker | The Investigator |
|---|---|---|
| Expectation from the environment | "Everything under control" | Clarity |
| Position | Part of socio-technical system | Outside socio- technical system |
| Orientation | Forward: What must happen? | Backward: What happened? |
| Related problem | Balancing risks; risk selection | Balancing expectations; factor selection |
| Problem handling | Implicit | Explicit |

accident—the tolerance for concessions to safety is low.

Investigation committees inevitably face a complex chain of events and have to arrange these into a clear, explicit report. They have considerable freedom to choose an approach. They have incentives to use a causal and casuistic approach: an approach that stresses the direct causes of an accident in the particular case. Adopting an alternative approach that focuses on the context and alternative cases is not attractive, because this blurs the message and makes the committee vulnerable to the criticism of "investigative bias."

A major weakness of the causal and casuistic approach is its tendency to ignore the risk-selection process in which the decision-makers are involved. This potentially undermines the probability that decision makes will learn from the report, because the reports will not reflect the tradeoffs the decision-makers faced. Adopting recommendations that do not address this process will not guarantee safety from a decision-maker's point of view. Therefore, they will not be eager to adopt the recommendations.

The perceived limited learning from investigation reports in fragmented organizational settings could be explained by the difference between the incentives of decision-makers and investigators. Table III summarizes this conclusion. Decision-makers and investigators of socio-technical systems are both concerned with safety, but in a very different way. Learning from disasters could be much improved if these two worlds would be aligned. It is a major challenge for investigation committees to accomplish this alignment.

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