BAM INFRA B.V.
&
TUDELFT

JUNE 2020

Creating Cross Organisational Safety Management

POSSIBILITY OF PUBLIC-PRIVATE SAFETY COLLABORATION

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This thesis is written in the partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (MSc)

in Construction Management & Engineering

At Delft University of Technology

Colophon

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Study Programme:	MSc Construction Management & Engineering

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Preface

You are reading my graduation thesis which is one of the fulfilments for the completion of the master Construction Management and Engineering. This document and the thesis defence mark the last element in order to graduate.

The topic of this research, safety, is something that always had my attention. I think we should always strive to work as safely as possible because no one wishes that another person gets hurt. People who have first-hand experienced an incident can be scarred for life. I think that every initiative that increases safety should be supported. In my experience, there is a growing interest for improvements to the safety performance, such as initiated by this research. I hope that the knowledge obtained in this research could help improve the safety performance of many organisations.

After years of theoretical courses, the change towards a more practical application of knowledge was very welcome. This research provides me with a new opportunity to combine theory and practice. During lectures about project management, one of the lecturers often mentioned that 'people are key' and during the research I often thought about this phrase. While this phrase is important in project management, it might be even more important in creating safety. Safety management revolves around the involvement of people. A set of rules cannot create safety on its own. The creation of attention to safety among people is a dynamic and complex undertaking. This research created the opportunity to experience this first-hand. And I experienced that working with people can be one of the hardest tasks of project management.

The graduation project took over a half year to complete and the result could not be reached without the help and guidance of the graduation committee. Special thanks to Pieter van Gelder, Frank Guldenmund, Marian Bosch-Rekveldt and Ruben Favié. Their input, feedback and suggestions helped tremendously in the forming of the research. The final product would not be of the same level and quality without them.
Secondly, I would like to thank all the people who contributed to this research by being available for interviews, providing information or just talking informally to discuss views. I could not have completed this research without their input and time.
Lastly, I would also like to thank the people at the graduating company BAM that welcomed me in their team, made sure I had an enjoyable time and provided the needed distractions. The chats and walks on the worksite were a welcome change from all the desk work and provided a look into the day to day life on worksites.

Luc van der Beeke
Haarlem, June 2020

Executive Summary

Safety is a hot topic, shown by the continuous interest, attention and research aimed towards understanding and improving safety performance. To contribute to this ongoing trend, this study focussed on finding an answer to the question how can safety be improved in a public-private construction environment? This research is executed in two phases, phase one is an exploratory investigation into the current problems in safety management and phase two is the in-depth investigation of a possible solution to the identified problems.

Phase 1 - Exploratory investigation

The focus of the exploratory investigation was to identify how safety is currently managed, what problems are encountered and which solutions could solve them. This investigation was executed with a focus on the procedures, methods and instructions that are used to manage safety since these form the basis on which safety management is built. This part of the research has been executed by means of investigating two practical cases in combination with a literature study.

From the literature it was found that safety management systems have been developed to manage safety in organisational settings. Current safety management systems are built around procedures, methods and instructions, and have a growing focus on creating a safety culture. Throughout history, there have been different schools of thoughts about safety, all with their own ideas on how safety is created such as Normal accident theory, High reliability organisations and the new Safety-II.
Despite the mature safety literature, safety remains a difficult aspect to improve. This is partly due to the complexity of construction projects, changing project conditions and working side by side with many organisations. This complexity will require different safety approaches compared to other industries, the unstable project environment possesses many difficulties in changing safety management.

From the cases it was found that safety becomes more salient during execution, people are more aware of safety in and around the worksite. Despite this positive development, results show that there are still several problems that harm the safe execution of the work. These are problems such as the mismatch between written procedures and the needs during execution, bad safety targets, safety management prescribed by management functions and differences in safety attitudes between organisations.

The combination of the literature and case study resulted in multiple possibilities for improving safety management, such as opportunities for a closer safety collaboration between project parties. Especially the involvement and contributions of clients can present an opportunity to help increase safety performance. Other identified improvement opportunities are found in the relative new safety principle Safety-II. This principle focusses on all safety actions in comparison to only the ones resulting in failures. Close collaboration between project partners in managing safety and incorporating Safety-II are found to be possibilities for improving safety management.

Because the safety collaboration opportunity suggests promising results and overlaps with the ambition of the graduation company, this opportunity is further refined from a broad concept to a specific opportunity. Based on similar research into collaborative safety management, a collaborative safety organisation between clients and contractors is a promising improvement opportunity. This safety organisation is tasked with co-operation, discussing and improving safety management between project parties. Based on literature, such a collaboration can be achieved. However, preconditions, mandate, composition and tasks should be clearly defined. This knowledge is currently unknown and therefore, further research is required in finding these characteristics of the new safety organisation. Phase 2 provides this further research.

Phase 2: Collaborative Safety Organisation

Interviews and an expert panel were used for the in-depth investigation of the new collaborative safety organisation. This method for managing safety requires more knowledge about the required characteristics, which are identified as preconditions, composition, mandate and tasks of the safety organisation. The results obtained indicate the safety collaboration should be in the form of a shared organisation, which would entail all parties (public and private) to collectively discuss, manage and improve their safety approaches. The data found resulted in the following conclusions.

Preconditions

There are different preconditions that apply in a public – private safety collaboration and these are mainly focussed on ensuring and continuing social interactions. The aspects required are the commitment of parties, need for an open culture, the leading role of the client, good relations between parties and maintaining these relations between parties. Additionally, parties should contribute resources towards the shared organisation and no party will have full control or power over the organisation. These preconditions have been found to be of importance for the success of the final safety collaboration.

Composition

The main body of the safety organisation will consist of parties' representatives such as safety managers or suitable replacements. This group will be called the safety meeting and their function is to execute the later identified tasks. Additionally, there is a response panel with workforce participants that will generate ideas, generate improvements and provide feedback. The combination of these two groups will form the safety organisation.

The response panel's function should be two-sided, it will act as an idea generator and as a sounding board for the safety meeting. The ideas, opinions, responses and irritations encountered during work execution could help to improve (current) safety practices. These aspects can be further discussed and possibly be implemented by the members of the safety meeting.

Mandate

The safety organisation needs to have a clear mandate to secure its position between the participating organisations. The safety organisation can best have an advisory role, since having a legal basis will result in responsibility problems. This advisory role should be supported by a social agreement, originating from the parties management' commitment. Results indicate that commitment can best be documented in a collectively written integral safety plan, which should contain tasks, responsibilities and obligations, and data of future meetings. The integral safety plan should put attention to the limitations of parties' responsibilities, they will not have control over workforces of others and they cannot transfer responsibilities to the safety organisation or other parties. The final integral safety plan should form the basis on which the collaboration is built and by collectively writing the plan all parties should accept the collaboration.

Tasks

The participating organisations should keep all legally required aspects in their own organisation. The safety organisation will only execute aspects that contribute to ambition to increase safety performance or aspects that increase the safety culture. Therefore the tasks executed by the safety organisation should form an addition, will coordinate or improve safety management aspects of participating parties.

The tasks executed by the safety organisation should be chosen by the parties themselves because prescribing could form resistance during the life-time of the organisation. Certain tasks are highly recommended to be centrally implemented, such as a central safety discussion, creation of vision and

goals, central safety communication, safety education, safety knowledge documentation and implementation of ideas from the workforce. Ideally, these aspects should form the basis of the organisation.

Additional tasks could be centrally executed when parties recognize these as suitable additions. Examples are safety rewards, co-ordination of safety inspections and central incident handling and inspection.

Practical application of the safety organisation

The generated results about the characteristics of the safety organisation give a rough outline of the organisation. While valuable, some extra practical recommendations can be useful during the implementation of the safety organisation. One of the first recommendations is to create clarity in the responsibilities within the organisation by using RASCI-matrices. This tool could help in creating a clear overview of responsibilities, accountabilities and other roles within the organisation.

The second practical aspect is that the safety organisation could benefit from having a coach taking the lead in the meetings. By ensuring structure and boundaries, it could be prevented that the meetings become long micro-managing conversations. This coaching or chairman position should not have the power to enforce opinions. The position is only tasked with ensuring structure and progress in the meetings.

The final recommendation is that the advices of the safety organisation should not be another layer of unnecessary safety documentation, which is the problem in most current safety management practices. The response panel, the workforce representatives, plays an important role in preventing more documentation. The representative's knowledge and experience must be used to determine the benefit of new procedures and their influence will help in achieving efficient safety management. Failure to listen and act on the ideas of the workforce will diminish the added benefit that the safety organisation could have.

Future Research

This research focussed on the characteristics of collaborative public-private safety management, which are required during the design and implementation phases. The long-term effects, adaptations or adjustments have not been studied, which will require more research.

Future research should investigate the long-term effects and adjustments required over the safety organisation's lifetime. Conducting this long-term research will make it possible to make claims about the impact of the safety organisation on safety performance. Currently, these effects are unknown but safety experts do expect improvements in safety performance with the implementation of the safety organisation. This shows promising opportunities to implement safety organisations, which could start to improve the safety performance in the construction industry.

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Cover photo:	Photograph from Arbo-Online (2018)
Phase 1, phase 2 & conclusion	Photograph from Vhmabc (2019)

List of Abbreviations

HRO	High Reliability Organisations
LMRA	Last Minute Risk Analysis
NAT	Normal Accident Theory
OHSMS	Occupational Health and Safety Management System
PART(ner)-plan	Planmatige Aanpak Risicovolle Taken- plan
RI&E	Risk-Inventory & Evaluation (Dutch: Risico-Inventarisatie & Evaluatie)
SMS	Safety Management System
TRA	Task Risk Analysis (Dutch: Taak Risico Analyse)
V&G	Veiligheid & Gezondheid (Safety & Health)
Safety Culture ladder	Veiligheidsladder (Certification to measure safety levels in organisation)

1. Introduction

To make clear why this research is conducted and what it is about, this chapter will describe the following aspects; the research context (1.1), the problem statement (1.2), the research objective (1.3), the research questions investigated (1.4) and a reading guide for the rest of the report (1.5).

1.1 Context

In November 2019[1], a road worker was working on the rush-hour lane and due to a missing physical barrier, a car hit this employee. Unfortunately, the employee passed away due to the sustained injuries. The construction sector scored highest on fatal victims in 2018, with 20 fatal accidents (Ministry SZW, 2019). In the last years, the number of fatal accidents in the construction industry has stagnated (Figure 1). However, the stagnation on a high number of fatal accidents shows that the current methods for managing safety should be reviewed.

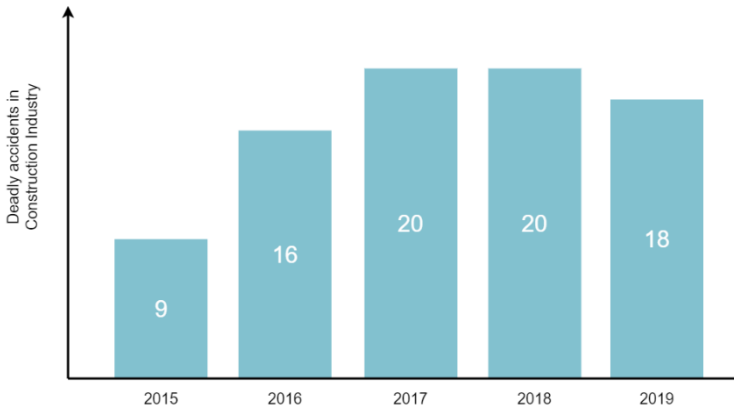


Figure 1: Fatal accidents in the construction industry (SZW, 2019)

The concept of safety does require some further explanation. Maurice, Lavoie, Laflamme, Svanström, Romer and Anderson (2001) describe safety as: ''a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community.'' They indicate that this definition does not make a good distinction between the concepts safety and security. Because security is defined as: 'protection against deliberate threats'' (SRA, 2018) and safety is defined as: ''protection against incidental accidents'' (SRA, 2018), the rest of this study will use the definition of Maurice et al. (2001) in the light of protection against incidental accidents (SRA, 2018).

There is an increasing focus on safety in and around the worksites indicating that companies start to prioritize safety (SZW, 2019). The phrase ''safety is a number one priority'' can be heard in many places. Despite the efforts made, the safety levels still need improvement. Often contracts are rewarded on the basis of a company's safety records or certifications, for example, their safety culture ladder certification (Busch, 2017). This highlights the focus on safety awareness, involvement and prevention activities. However, these aspects remain difficult to incorporate in the mind-set of the everyday workforce (Hudson, 2007).

Creating a safe work environment is already difficult in a singular construction company or project, in environments that consist of multiple employers with different backgrounds this will become even harder. There are many aspects that interfere with safe working conditions, such as the complexities and dynamics when multiple parties work side by side. This creates problems with different safety practices, procedures and instructions, therefore the advice is given to co-operate with safety management aspects (Nenonen & Vasara, 2013) and while some safety management collaborations exist, this is not a widespread approach in projects.

A current development in the Dutch industry is the increased interest of cliental parties in the (daily) management of safety. ''Clients start to acknowledge that the safe execution of work is partly their responsibility and that they can greatly influence the safety outcomes'' (Quote: Director BAM, 2020).

[1] Accident Waterloo 06-11-2019

This is a trend seen in the entire construction industry. Recently, the Dutch research council for safety (OVV, 2020) stated that large contractor and client parties are aiming for more collaboration between all parties to achieve safety in their work. While it is accepted that the client can influence safety performance (Liu, Jazayeri & Dadi, 2017), the daily management of safety is currently not accepted as part of the client's influences. The trend that public clients start to be involved in daily safety management requires more research.

1.2 Problem Statement

Safety is a relevant topic nowadays. The increasing (contractual) pressure of public parties to improve safety levels asks for better safety practices (Ashworth, 2006; Liu, Jazayeri & Dadi, 2017). The constant high number of fatal accidents in the Dutch construction industry shows that the current use of safety practices is not enough to reach the desired levels of safety (Ministry SZW, 2019). Rozenfeld, Sacks, Rosenfeld and Baum (2010) show that the construction industry is unique in its characteristics and this uniqueness is the origin of many of the problems in achieving safety. Construction projects are dynamic and experience many changing factors (workers, work and site conditions) which make achieving safety more difficult (Rozenfeld et al., 2010).

The construction industry is increasing its attention towards safety performance, the companies put forward ambitions to increase their safety performance and put it as a top priority (Bouwend Nederland, n.d.). The combination of high safety ambitions and continuously occurrence of fatal accidents show that further research into the safety performance of the construction industry is required.

1.3 Research Objective

The goal of the study is to first identify improvement opportunities for safety management, and second to use these opportunities to further investigate a method that could increase safety performance. This research will also add to the safety literature available. Research into the safety management of multi-actor collaborations is sparse and the safety collaborations between public clients and private contractors are hardly investigated. The opportunity to investigate such collaborations could create new insight and help fill the literature gap currently present.

The research has theoretical- and practical contributions.

- The theoretical contribution of the research is that it adds to the safety literature, as well as to the multi-actor safety collaboration literature by showing the needs and improvement opportunities in public-private safety collaborations.
- The practical contribution of this research is that it provides insight in practices used in a client - contractor collaboration to increase safety levels collaboratively. Other companies could use the conclusions of this research to focus their safety efforts and to help improve the safety practises of the industry.

1.4 Research Question

The combination of the context, problem statement, objective and the literature gap results in the following research question.

How can safety management be improved in a public-private construction environment?

The main question can be built up by different parts. Different sub-questions are formulated to help answer the main research question. The following sub-questions are defined:

1. *What is the current theoretical knowledge about safety management?*
2. *How is safety management practically applied in construction environments?*
3. *Which improvement opportunity should be further investigated for application in a construction environment?*

*B*ased on the answers to sub-questions 1 to 3, the following further sub-questions are stated.

4. *What are the preconditions needed for the public-private safety organisation?*
5. *Who should be included in the public-private safety organisation?*
6. *What is the mandate of the public-private safety organisation?*
7. *Which tasks should be performed by the public-private safety organisation? Which tasks should be carried out by others?*

1.5 Structure of Report

Chapter 1 and 2 describes the introduction to the topic and research and discusses the research design. Chapter 3 and 4 are the phase 1 investigation, which focusses on exploring the current situation and trend(s) to improve safety. This is done by finding current knowledge about safety and how it is managed in organisations. Sub-questions 1, 2 and 3 will be answered in this section.
Chapter 5 and 6 focus on the phase 2 investigation, which will focus on a possible solution for solving the problems in the construction industry. By investigating the possible solution and its characteristics, it is possible to answer the rest of the sub-questions (4, 5, 6 and 7). The final part (chapter 7 and 8) will include the discussion and conclusion, this section answers the main research question.

2. Research Design

This chapter describes how the research is designed. Section 2.1 describes the characteristics of the research, section 2.2 contains the scope of the project, section 2.3 describes the selection of data sources and the final section, 2.4, displays the research framework.

2.1 Research Characteristics

Every research (qualitative, quantitative, mixed methods) has its own strengths and limitations (Sekaran & Bougie, 2013). What kind of research method should be used, is influenced by the goal of the research and its research question. This research can be characterized as qualitative research. The main research question: *''How can safety be improved in a public-private construction environment?''* is best approached in a qualitative manner because ''Qualitative research is uniquely suited for opening the black box of organisational processes, the how, who and why of individual and collective organized action.'' (Doz, 2011, p. 583).

Phase 1, Exploratory investigation

Before investigating the method for improving project safety performance, it is useful to understand the underlying aspects and problems of the project environment. Therefore, the research starts with an exploratory investigation phase. A combination of literature research and case study is used to identify current problems in safety management and to explore safety improvement opportunities. The choice for a case study is made since Sekaran and Bougie (2013) state that case studies are useful for exploring phenomenon in their natural surroundings. This approach has strengths such as gaining insights into the context, in-depth understanding and the explorations of causal effects in detail. This is particularly relevant for this research because it is important to explore the actual (practical) problems within the cases. The knowledge obtained will be used to identify an improvement opportunity, which can be further investigated in phase 2.

Phase 2, Investigation Improvement Opportunity

The results found in the exploratory phase will be used as the basis for the next phase in which a new safety approach is examined, see Figure 2. Sekaran and Bougie (2013) argue that using a series of interviews is best suited for generating knowledge on a new topic. Therefore, interviews are the main data source for this phase. The results of the interviews will be compared with another data source, an expert panel. ''Expert panels are used for making generalizations based on the information generated by them'' (Sekaran & Bougie, 2013, p.122). This is a valuable addition to the research and improves the research' validity.

By comparing results from different data sources, the internal validity[2] of the research is increased. External validity[3] is ensured by comparing results with literature. The collective public-private safety approach is new with no existing literature to support this relation. It will be compared with existing safety and collaboration/partnership literature. During the research, every step and consideration will be explained and data generating protocols will be available (Appendix A, B and C). By ensuring that the research path is clear and information is available, the reliability[4] of the research is ensured.

Figure 2: Relation between phase 1 and phase 2 (own illustration)

[2] Internal validity: the relationship between variables and the obtained results (Sekaran & Bougie, 2013)
[3] External validity: the relationship between the results and the outside world (Sekaran &"Bougie, 2013).
[4] Reliability: the unbiased and errorless nature of the data obtained (Yin, 2003)

2.2 Research Scope

The research is focussed on aspects that are manageable within the available timeframe. The research should be executed in a period of 6 months. This research focusses on the construction industry because this industry is still struggling to increase their safety performance. It is marked as a high-risk industry (Nygren, 2018), resulting from hazards in the physical work environment and the presence of unsafe work processes and practices (Radomsky, Ramani & Flick, 2001). The need to increase safety performance in this industry forms an opportunity for new safety initiatives. As mentioned before, the safety collaboration between client and contractor is hardly investigated and this research will focus on how these public and private partners can collaborate on safety aspects.

Regulations and legislation differ per country, the choice is made to limit the research to the Dutch construction industries. Safety is such a broad construct that a focus should be made. Dekker (2014) explains that safety can be achieved by having a basis of procedures and rules, this basis can be used to build upon with additional tools. The choice is made to have a focus on these base procedures, investigate their applicability, usefulness, problems and practicality.

2.3 Selection Data Sources

Case study HOV 't Gooi

From the graduation companies' portfolio, one of the projects had the ambition to increase their performance on safety. The project HOV in 't Gooi will be used for investigating the problems in ensuring safety and to determine aspects that could be improved. This will be done by investigating the procedures set, and how these are used in practice.

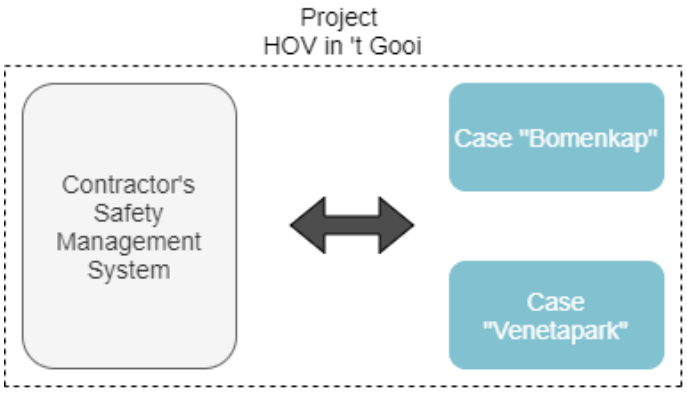


Figure 3: Overview exploratory phase (own illustration)

Within the project, two cases are investigated (Figure 3), a combination of observations, interviews and document reviews will be used to collect data. The selection of cases can be described as a convenience sample approach (Sekaran & Bougie, 2013), because the cases are selected based on their execution during the research, and the ability to thoroughly investigate them. The two practical cases (marked in blue, Figure 3) are selected to present an overview of typical work executed in the industry. To understand the environment in which these cases are executed a thorough document review is conducted which focusses on the safety management procedures, instructions and methods required (marked in grey, Figure 3).

The project HOV 't Gooi is an infrastructure project with the goal to create a new bus line between Hilversum and Huizen. The construction of the new bus line is a complex undertaking due to the densely populated area, because it intervenes with other active infrastructure (car/bike roads and a rail line) and it crosses a natural reservation. The project is commissioned by ProRail, Province Noord-Holland and the municipality Hilversum. These parties value the creation of a project that is as safe as possible, which aligns with the ambition of the main-contractor BAM. Collaboration between the parties is one of the project goals and safety in the project is considered to be a shared responsibility.

Investigation Improvement Opportunity

The second phase of the research is investigating a concrete improvement opportunity, which will be done by means of interviews and an expert panel (Figure 4). These research methods are selected based on their applicability in qualitative research (Sekaran & Bougie, 2013). After the selection of these methods, it is important to create clarity over the selection of participants.

Figure 4: Overview research methods for investigation phase 2 (own illustration)

The people participating in these research methods are selected on their knowledge, suitability and experience that relate to the topic of the research. The safety topic results in people who are knowledgeable about safety, have sufficient experience with safety management and who represent a wider selection of the construction industry. The last aspects, representing a wider selection of the construction industry, will be important to ensure. The topic of this research is focussed on the construction industry and therefore is this wider representation an important aspect to ensure during the selection of participants.

The selection of interviewees and expert panel participants represents a large section of the construction industry, these respondents have experience in different specialisms in the industry. Ranging from having experience in one or multiple industries such as civil (rail, road, water), utility or chemical. All respondents have sufficient knowledge about safety and safety management in construction projects. Further information about these research methods, characteristics and data source selection is presented in chapter 5.

2.4 Research Framework

As mentioned, the research is divided into multiple phases, these phases are related to the sub-questions raised in the previous chapter (1.4). As illustrated in Figure 5, these parts correspond with different phases in the research. Starting with an exploratory investigation (phase 1) into the current procedural problems in safety management. Followed by an investigation of the proposed safety improvement opportunity (phase 2) and its characteristics and application within an organisation. The final part of the document will conclude and discuss the results found.

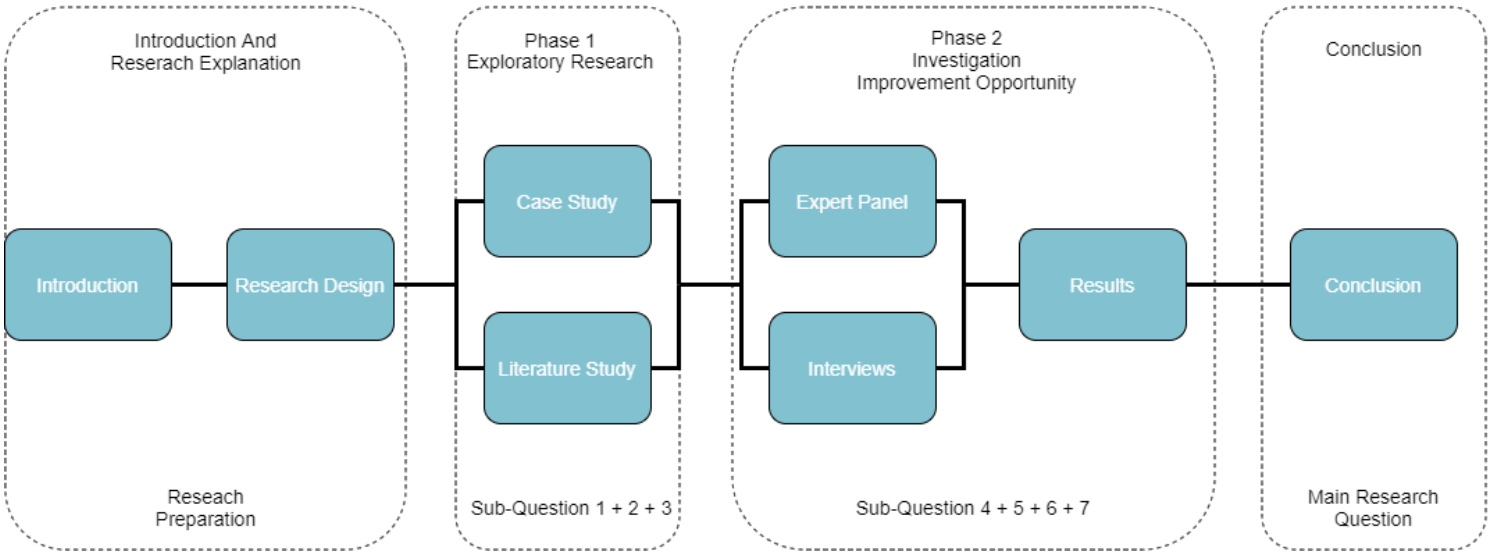
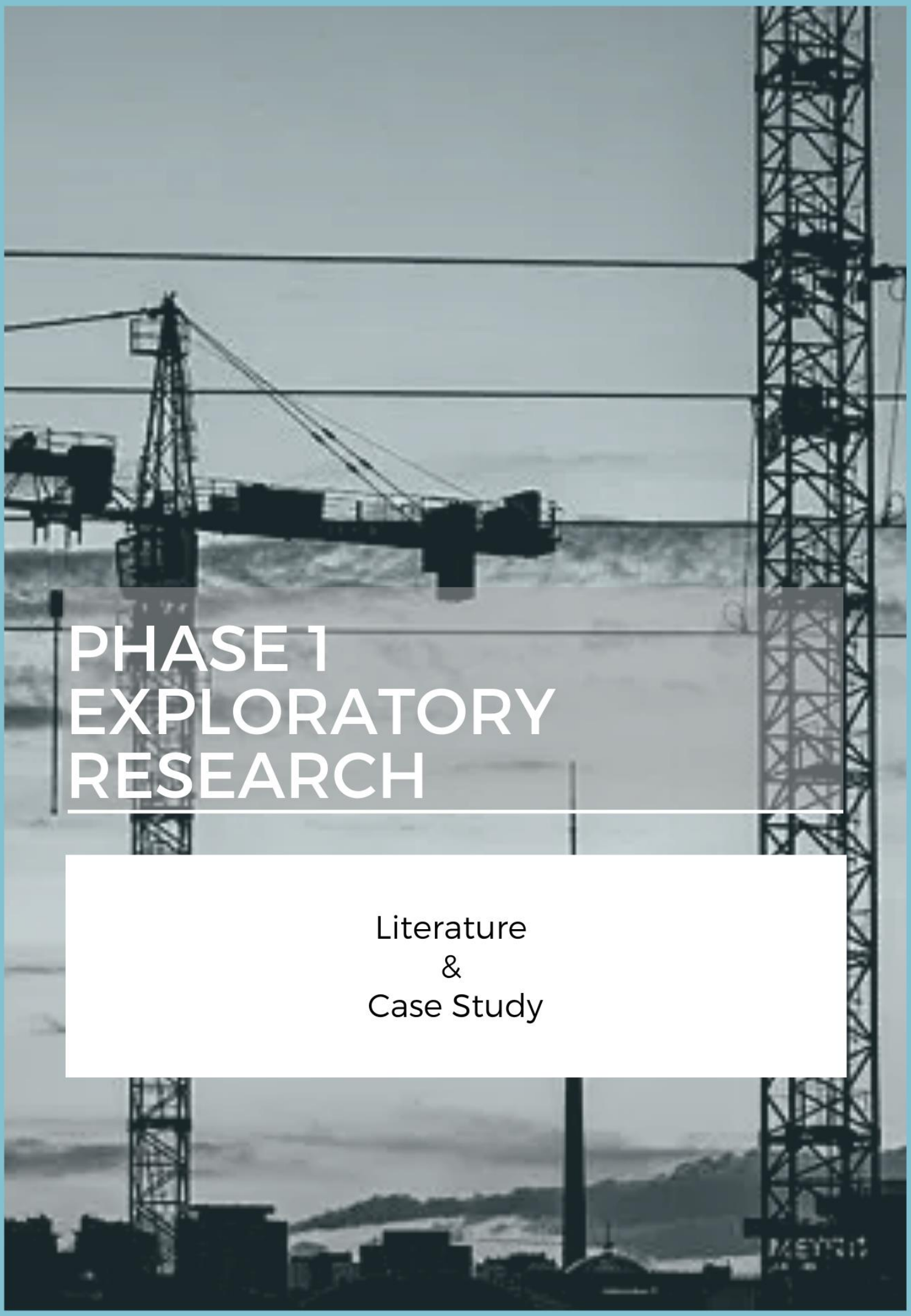


Figure 5: Overview of the research framework (own illustration)



PHASE 1 EXPLORATORY RESEARCH

Literature
&
Case Study

3. Literature

This chapter will elaborate on the current practices to manage safety, which are identified by studying the publications within the scientific field. The literature study will help with building a frame of reference and identify safety improvement opportunities. This chapter will focus on what has been researched in the past, what interesting conclusions can be used and what gaps in the current literature can be identified.

As a starting point for the literature research, a series of concepts have been selected based on the research question posed in section 1.4. The following words have been selected as guiding: safety, collaboration and safety procedures. Supplemental keywords have been gathered, which were used to search for relevant literature. In Table 1 the supplemental keywords can be seen. The researcher used different platforms for finding relevant literature, such as Scopus, Google Scholar and Science Direct.

Table 1:
Concepts used in the literature study.

Safety, safety management, health & safety, occupational safety, OHS, SMS
Collaboration, multi-employer, multi-actor, public-private, private-private, organisations, co-operation
Procedures, rules, regulations, plans, measures, policy
Client, public parties, principal, owner, government, employer
Infrastructure, construction, industry, oil-gas, chemical, residential

Since concepts are not used consistently in the literature, it is difficult to collect all relevant articles. The technique of snowballing effect is therefore used, which is to start with an interesting article and by looking at its references, other relevant articles in this specific field can be found (Verschuren & Doorewaard, 2010).

The rest of this chapter will discuss the following aspects. How is safety managed in organisations (section 3.1), the safety methodology guiding safety management in section 3.2, safety collaboration (section 3.3) and the final section 3.4 will present a conclusion. This chapter will be used to answer the first sub-question:

What is the current theoretical knowledge about safety management?

3.1 Organisational Safety Management

There are different elements that influence the safety of a work environment. For controlling all safety elements, organisations have incorporated safety management systems (SMS) with the purpose of ensuring safe environments and consequently preventing unsafe (working) conditions.

Across companies, scholars and industries there are different definitions for such systems. The International Labour Office (2009, p. 19) defines a safety management system as ‘’a set of interrelated or interacting elements to establish occupational safety and health policy and objectives, and to achieve those objectives’’. Safety management systems are commonly used in high-risk industries such as the construction industry.

A safety management system generally consists of several elements. Each covering a particular area of interest for safety which should be managed or controlled. The management or control of this area usually follows the well-known Deming-circle, Plan-Do-Check-Act routine, with each cycle the area of interest should be further improved.

Safety Management System' Elements

Similar to the lack of a consensus on the definition of a safety management system, there is also a lack of consensus on the specific elements of the SMS. Different frameworks have been developed that provide a list of them to be incorporated elements. An example is the Oregon OSHA Safety and Health model (OSHA, 2005), which indicates six general areas of interest. These are displayed in Figure 6.

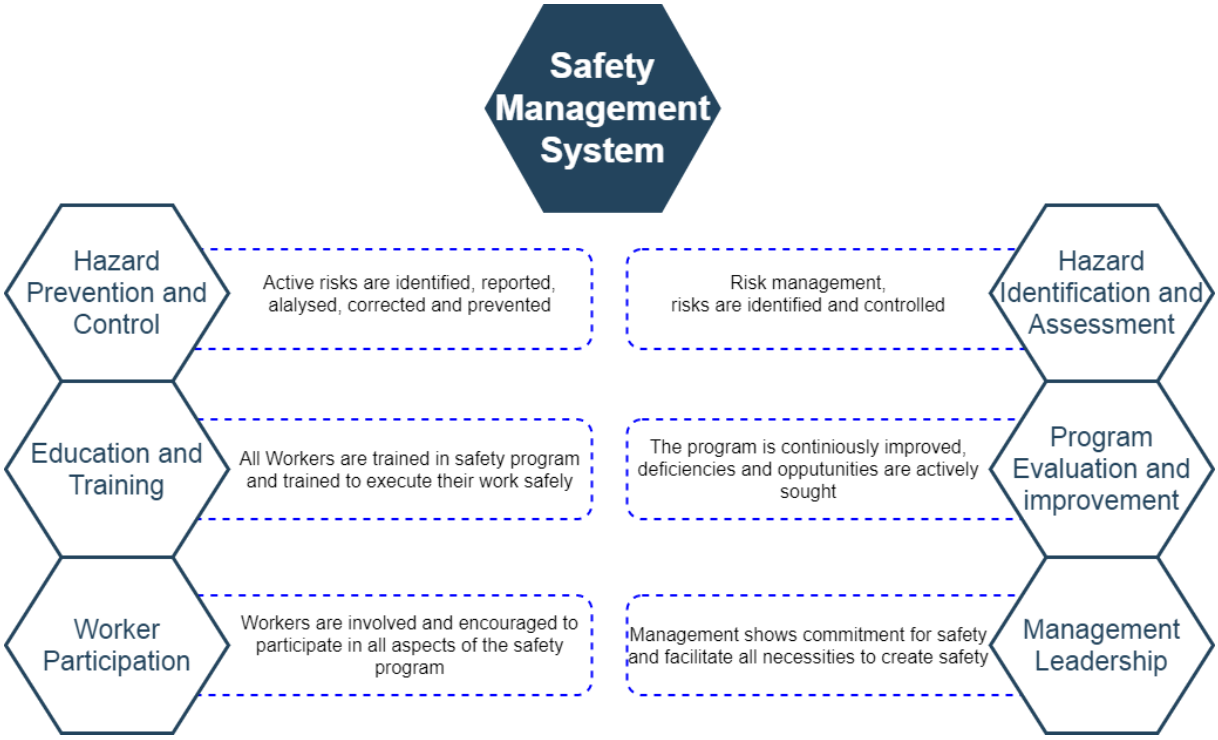


Figure 6: Overview of essential elements of SMS (own illustration)

The exact design of these elements will differ among companies. Different sources (e.g. LaMontagne, 2004; Petersen, 2005; Jazayeri & Dadi, 2007; Robson et al., 2007; Crutchfield & Roughton, 2014; Alarcón, Acuña, Diethelm & Pellicer, 2016) indicate slight variations or more detailed explanations of these elements. The models that describe safety management systems are broad and they indicate general aspects but do not elaborate on the specific elements. This allows organisations to fill in the exact procedures by themselves.

There is a seventh element in the SMS model by OSHA (2005); Coordination and Communication on Multiemployer Worksites. This aspect is not specifically mentioned by the other scholars, originating from the fact that the OSHA model is aimed at construction companies. In the construction industry, it is more common to work with interorganisational collaborations, making this element important to include. The OSHA model describes the content of the multi-employer aspect as the communication and coordination of work planning, risks, conflicts and hazards between all involved parties.

In order to determine the degree of implementation of SMS' elements, there are different certifications such as VCA, Safety Culture ladder, OHS18001 or ISO45001 certification. These grade the maturity of the safety system, the ability to improve and the ability of the company to work safely. The certifications are often used to comply with the mandatory regulations set by governments, in the Dutch construction industry the safety culture ladder is an important tool used for certifications. The safety culture ladder certifies similar aspects as presented in the OSHA (2005) model (GCVB, 2019), see Figure 6.

Safety Improvement

The study by Robson et al. (2007) shows that implementation of such (mandatory) safety systems has favourable results, such as increased Health Environment and Safety (HSE) awareness and increased employee participation. Seen in e.g. increased hazard reporting, increased safety culture and a decrease in injury rates.

Hale, Guldenmund, van Loenhout and Oh (2010) went further in investigating the individual elements of safety systems that do or do not have an influence on the level of safety. The findings are in line with the aspects noted before. Some of the implemented elements of SMS do indeed have a positive influence. Factors such as support of higher management, the contribution of a coordinator, starting the dialogue between employees, training of the managers, and aligning interventions with the workers' needs.

The research by Alarcón et al. (2016) investigated the relation between prevention activities and accident rates. The main conclusion is that ''the choice of the right combination of these practices was more important than just the number of practices implemented'' (Alarcón et al., 2016, p. 116). A focus on the combination of training & audit, workers' safety training, and management safety training will create the lowest accident rate. Despite incentives and rewards being the most effective category, a lack of data prevented a conclusion to be drawn on this aspect.

Disadvantages SMS

Problems in safety management could be linked to problems of such systems themselves. The performance of such systems is often measured afterwards by lagging indicators e.g. incident rates (Hinze, Hallowell & Baud, 2013). This creates the problem that the system is reacting instead of acting which is perceived as decreasing the usefulness of the system. Another problem found is that SMS can become overly complex, with much rules, paperwork and procedures. The often-used solution is to increase the number of procedures and paperwork, which has a negative influence on the usefulness of the system. Employees state that this is a barrier for reporting incidents and following procedures (Milch & Laumann, 2016), again decreasing the usefulness of the system.

The above section shows that safety management systems help with setting procedures, methods and instructions with the aim of achieving safety but accidents can still occur. The next section will look into the principles that lay the basis for such safety management systems.

3.2 Principles Guiding Safety Management

In the Netherlands, all companies and most projects are obliged to have implemented a safety management system. Safety management systems are perceived as an effective way to increase the safety performance of a project (Yiu, Chan, Shan & Sze, 2019). In this part of the chapter, a couple safety methodologies will be discussed to look for improvement opportunities in managing safety. These are Normal accident theory, High Reliability Organisations and Safety-II.

History Safety Management

When safety management systems were originally developed, they were applicable for predictable and simple processes. Where risks could be solved with procedures, safety management was based on risk assessment and planned risk control (Perrow, 1984). When the complexity (non-linear and tightly coupled processes) of the processes increases, safety management systems will react by imposing high amounts of procedures.

Central to the Normal Accident Theory (NAT) (Perrow, 1984) is the idea that accidents in complex and dynamic systems cannot be prevented. Over time there will be a moment that disaster will happen in such systems. A build-up of assumptions, changes and adaptions to the system can create opportunities for accidents (Shrivastava, Sonpar, & Pazzaglia, 2009). These complex and chaotic circumstances make it impossible to create a model that will predict the accident. Scholars indicate that no model is available that describes the causes of an incident in a linear way (Svendung & Rasmussen, 2002; Haslam et al., 2005; Dekker, 2014; Woolley, Goode, Read & Salmon, 2019). The causes of an incident are the result of ''multiple, interacting and contributing factors'' (Woolley et al., 2019, p. 536). This makes it currently impossible to anticipate and prevent accidents before they happen.

Dekker (2014) explains that a safety management system is useful, but there is a point where additional procedures or rules will not create any benefit. When a certain base level of safety is reached, extra procedures will not result in higher safety levels. To increase safety beyond system safety (procedures & rules), focus on behaviour, leadership and other aspects of culture is needed as can be seen in Figure 7.

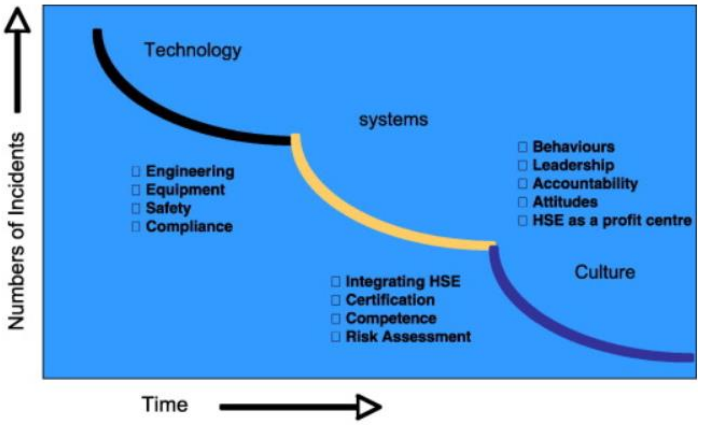


Figure 7: Development line, culture becomes the next wave after systems safety (Hudson, 2007)

High Reliability Organisations

High reliability organisations (HRO) are organisations that operate in a high-risk area with complex and chaotic systems (Dekker, 2014). Their safety records show that despite operating a non-linear and coupled system, it is possible to achieve good safety records. Some examples of high reliability organisations are nuclear reactors, oil rigs, aircraft carriers and air traffic control. These all operate with non-linear and coupled system, while maintaining high safety levels.

Results show that HRO's have specific characteristics that make them different from others. These organisations show a strong focus on their ability to solve and fix the system when disturbed because HRO's have created resilience to cope with dangers (Sagan, 1995). There is a strong focus on the prioritization of safety among all levels, redundancy in resources and systems and improvements of the safety culture. Rochlin, LaPorte and Roberts (1998) found that there are six aspects that are required of an organisation to achieve HRO status, which are:

1. Leadership safety objectives
2. Maintenance of relatively closed operational systems
3. Functional decentralization
4. The creation of a safety culture
5. Redundancy of equipment and personnel
6. Systematic learning

Many other scholars (e.g. Libuser, 1994; Roberts, 1990; Roe, 2004; Binci & Cerruti, 2012; Pettersen & Schulman, 2019) found similar aspects that are present in high reliability organisations. In practice, these can be identified as a clear set of safety goals, decentralization of authority for (safety) decisions, learning culture focussed on trial-and-error learning, redundancy in resources and a general aversion against change (in procedures) (Roberts, 1990). When HRO's focus on these six aspects, it makes them able to achieve high safety performance.

Unfortunately changing the mindset of an organisation towards an 'HRO mindset' is difficult. Especially, because many of the aspects that are required to become a HRO require culture change. Besides the safety culture requirement raised by Rochlin, LaPorte and Roberts (1998), the other aspects also should be deeply embedded in the people and in the organisation. This will require years of work to change the culture within an organisation (Hudson, 2007).

As seen in the SMS models (OSHA, 2005), fundamental aspects of HRO's are incorporated in the management systems. For example, making employees capable of recognising and acting on safety risks, focusing on safety culture, and auditing the process to look for continuous improvements. Even in HRO's accidents can still happen, history tells that some of the safest oil rigs can have a fatal accident after years of excellent safety performance (e.g. oil rig Deepwater Horizon in 2010).

Safety-II

Currently, safety management mostly focusses on the prevention of accidents by looking at previous accidents. Determining what went wrong and using this knowledge to prevent similar accidents from occurring. This focus on what went wrong is called Safety-I (Dekker, 2014). Beus, McCord and Zohar (2016) show that the lack of accidents does not necessarily mean that work is executed safely, work can be executed hazardously without resulting in an accident.

Different names have been given to this new manner of thinking e.g. Safety differently, Safety-II and Resilience engineering (Nemeth, Hollnagel & Dekker, 2009; Dekker, 2014). The central idea is to ''look at what goes right as well as what goes wrong and learn from what works as well as from what fails'' (Hollnagel, Wears & Brathwaite, 2015, p. 28). As can be seen in Figure 8, Safety- I focusses on the accidents and disasters that occur sporadically (the unwanted outcomes at the left of the Figure). While Safety-II also focusses on the rest of the outcomes, that not necessarily lead to a negative outcome (accident or disaster) or that have a positive outcome, Thus, going from only focussing on the red area, in Figure 8, towards a focus on the whole distribution.

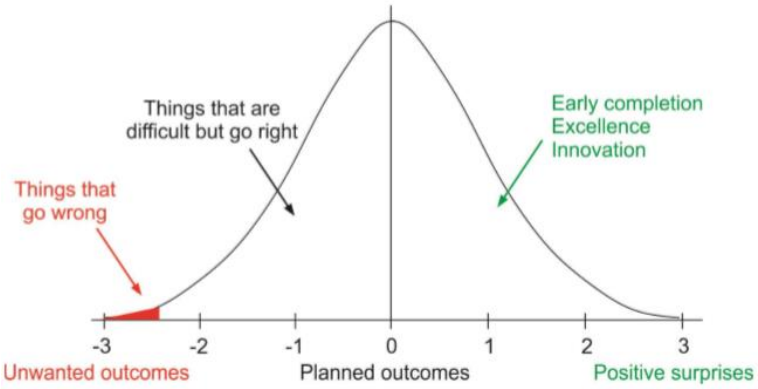


Figure 8: Probability of event occurrence (Hollnagel, Wears & Brathwaite, 2015)

Safety-II thinking should not replace the original manner of looking at safety. Learning from incidents will remain of importance. In practice, Safety-II should be used as an addition to current practices. For example, current practices can be improved by adopting a different focus in safety inspections, looking further than bad practices and look for good practices. This is a relatively new development in safety management, but it is viewed as something that could make a significant impact on safety (Hollnagel et al., 2015). There will be a need for some new methods, as Casey, Neal and Griffin (2019) explain, there is a need for new consultative and participative approaches to safety management.

In many aspects, Safety-II thinking is similar to HRO. Both value the importance of empowering people to detect and prevent accidents (Haavik, Antonsen, Rosness & Hale, 2019). The main difference is that HRO looks at a long-term focus on building and increasing a safety culture. Safety-II, on the other hand, has a more short-term focus on the everyday interactions between people and on how work should be done versus how it is actually done (Haavik et al., 2019). The Safety-II methodology should not be a competitor with HRO, instead it should be a complementary factor to HRO practices (Haavik et al., 2019).

In the above section, it became clear that there is a current focus on Safety-I but that Safety-II can add to this perspective. It is a new perspective and needs more research but because of its wider view, it is a promising perspective. Because this research focuses on collaborative safety management, it is interesting to discuss collaboration literature. The next section will focus on this.

3.3 Safety Collaboration

While creating a safe work environment is already difficult in one company, in (project) organisations that consist of different organisations with different backgrounds this will be even harder. ''The management of workplace safety has become more complicated in a multi-actor arrangement in various industry sectors'' (Nygren, 2018, p. 173). Almost all safety collaborations research focusses on the relation, specifically the problems, between multiple contractors working side by side (Priemus & Ale, 2010; Nenonen & Vasara, 2013; Cedergren, 2013).

Scholars investigating the problems showed the problems during multi-actor safety management. Some examples are poor selection of providers, lack of resources, ambiguity in responsibilities, weak commitment, complexities in management and supervision, dangerous work tasks and practices, insufficient communication, differences in working cultures and insufficient hazard identification (Mayhew, Quintan & Ferris, 1997; Priemus & Ale, 2010; Nenonen & Vasara, 2013; Cedergren, 2013).

The literature review conducted by Milch and Laumann (2016), shows only a small set of articles describing safety issues related to inter-organisational complexity. Among the different articles they found four major topics that were identified by all scholars, which are:

- Economic pressure: Safety-production trade-off
- Disorganisation: Confusion of roles/responsibilities
- Dilution of competence: Differences in safety skills/experience
- Organisational differences: Differences in work habits/practices.

Successful collaboration between parties will require agreements and attention put towards these aspects, differences between the parties must be lowered (Milch & Laumann, 2016). It was identified that these problems result from forcing methods on other parties, by adapting the safety management system of one of the main (constructing) parties.

Similar problems can also be seen in partnering or alliances, were three safety management approaches can be adapted. All parties can keep their own management systems, adapt one management system (of one of the involved parties) or they can build an entirely new system. These options have their own problems, collaboration issues, resistance to change and difficulty in creating such systems (Vassie & Fuller, 2003).

Towards Co-operation

Described literature illustrates that forcing one safety management method on all parties will create problems. Opportunities are identified to co-operate with the implementation of safety activities and overlapping safety operations, which would help to overcome most (safety collaboration) problems encountered (Nenonen & Vasara, 2013).

Hale (2001) studied a collaboration case where the parties tried to initiate an organisation aimed at safety co-operation. This scholar studied the safety management of Schiphol airport after the Bijlmer crash, in this case there was a strong focus on creating a collective safety approach. This was done by creating an integrated safety management system (ISMS), which is an independent organisation that coordinates safety practices among the parties involved. Some aspects that normally only occur in the company's SMS were coordinated at a central level, such as the investigation of accidents, the improvement of safety practices and the communication of safety among organisations. The research

shows multiple problems encountered, the major ones were the ISMS's responsibilities, the commitment of actors and difficulties in the ISMS' power.

Role Client

Normally the client has a unique position since they have the power to enforce their will on the contractors. This can already be done by the selection of contractors during the tendering phase (Jazayeri & Dadi, 2017). During day to day interactions on the shared worksite, the client has again opportunities to enforce its power (Nygren, 2018). Liu, Jazayeri and Dadi (2017) indicate that the client has an influence on the following aspects which (indirectly) influence the final safety performance.

- Establishing attitudes towards safety
- Communicating attitudes towards safety
- Selection of contractors
- Contractual safety arrangement
- Owner involvement in safety before construction phase
- Monitoring contractor safety compliance

More clients' attention towards these aspects would have positive effects on the safety performance achieved by projects. One of the highest valued contributing factors to overall safety is the 'monitoring contractor safety compliance', an owner's focus on this factor is perceived to increase the total safety performance (Liu, Jazayeri & Dadi, 2017).

Huang and Hinze (2006) identified that the project owners are becoming more involved in safety management and their involvement can be seen during all project phases. Projects with actively participating owners are performing better and achieving lower safety numbers (Huang & Hinze, 2006; Gambatese, 2000). Both scholars indicate that the safety attitude of proactive owners is part of the reason why the petrochemical industry has such a high level of safety performance. Having both client and contractor actively focusing on safety (management) will have a great influence on the final safety performance (Huang & Hinze, 2006; Lia, Jazayeri & Dadi, 2017).

While a trend is seen in participating owners in safety management, in practice this remains difficult. Owners do not have a direct influence on safety management, which is a task normally executed by the contractors. For clients to participate in safety management, safety management collaboration is required (Gambatese, 2002). In the literature a gap is identified, to managing safety as a true collaboration between client and contractor, such collaborations between public and private parties are hardly studied.

3.4 Conclusion

After reviewing the existing literature, it is possible to answer sub-question 1 from a literature perspective:

> SQ1: What is the current theoretical knowledge about safety management?

Safety management systems have been developed to manage safety in organisational settings. Current safety management systems are based on procedures, methods and instructions, and have a growing focus on creating a safety culture. Throughout history, there have been different schools of thoughts about safety, all with their own ideas on how safety is created and how problems arise. Safety management systems incorporate different aspects from these safety methodologies. For example, aspects from HRO and basic NAT aspects can be identified in safety management systems.

Despite extensive safety research, safety remains an aspect which is difficult to improve. The development of a useful and effective safety management system takes time. It takes years to improve safety levels and to make safety a common practice within the organisation. The changing project conditions with more parties involved will require different safety approaches. The increased complexity of such environments will require more effort and resilience from the workforce, which is a difficult process.

Literature about safety collaboration show that collaboration in safety management could form an opportunity with a positive effect on the final safety records. Especially, the involvement and contributions of clients can present an opportunity to help increase safety performance. Other opportunities for improving safety are identified in the relative new safety principle Safety-II. This principle focusses on all actions in comparison to only the ones resulting in failures. Safety procedures based on Safety-II methodology have hardly been developed.

4. Project's Current Safety Problems

This chapter is the start of the practical research and will describe the procedures, results and conclusions obtained from conducting a case study. The following paragraphs will describe the goal (4.1), the selection process (4.2), the research method (4.3), the results obtained (4.4), the comparison of the results (4.5), and the conclusion (4.6).

The results of this chapter will be used to answer sub-question 2:

How is safety management practically applied in construction environments?

4.1 Goal of the Case Study

The goal of this case study is to investigate the application of safety procedures and rules in practice in order to identify improvement opportunities for safety management. The cases compare how safety 'should be done' (written down in procedures and rules, also 'work as imagined') to 'how it actually is done' (behaviour during execution). This is respectively investigating the safety management system, Case ''Bomenkap'' and Case ''Venetapark''.

4.2 Selection of Cases

As introduced in section 2.3, the project HOV in 't Gooi will be investigated to identify safety problems during execution. Two cases within the project will be investigated, as can be seen in Figure 9. The safety management system is investigated to understand the procedures implemented in the company and project. The goal is to investigate how safety should be executed or implemented. Two cases are investigated to see how the procedures are actually applied in practice.

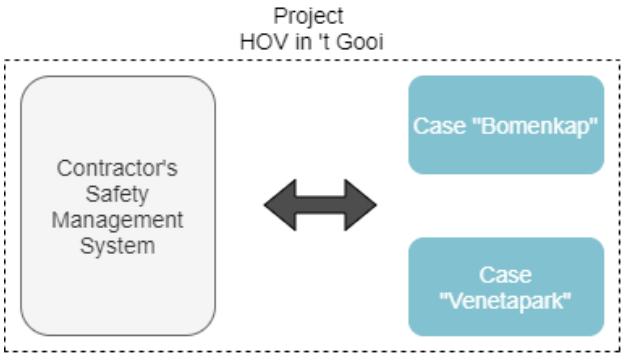


Figure 9: Display of cases investigated (own illustration)

The next paragraphs will provide more information about the two cases and the investigation of the safety management system. First, the safety management system investigation is illustrated (4.2.1). Second, the case 'Bomenkap' is described (section 4.2.2) and lastly the case 'Venetapark' is presented (section 4.2.3).

4.2.1 Description 'Safety Management System BAM''

The BAM Group B.V. has a company-wide safety program which should help to create safety for every employee. All BAM companies have applied the same basic safety management structure, but specific work will require different procedures. This also holds for differences between projects, each project will create its own set of procedures resulting in slight variations.

To gain more insights into the current safety procedures, the project's safety management system will be investigated. This system is designed, implemented and maintained by the main contractor of the project (BAM Infra). It contains all processes, procedures and instructions implemented in the project. This system is designed by the safety manager, who designed the system based on similar project executed by the company and on his or her own experience and knowledge.

4.2.2 Description Case ''Bomenkap''

The first practical case observed is the preparation of the overall worksite. This task consisted of felling and removal of a couple of hundred trees. Most of them were located in forests or parks, but a couple dozen trees were located on streets which were still open for traffic. Besides the dangerous worksites, the felling of trees itself is also considered as a hazardous undertaking. Hazards of falling objects,

collisions with machines and dangerous cutting machines (chainsaws) are some of the hazards present. These risks have been identified beforehand, presented in a workplan (Ned: werkplan).

Multiple tasks are executed at the same worksite; placement of a new gate, felling of the trees, removal of the branches and logs and the chipping of the tree stumps. These tasks are executed side by side and require all workers to ensure their own safety but also the safety of bystanders. The tasks are executed by sub-contractors who are employed by the main contractor.

During the execution of these tasks an incident happened. During the felling of a tree, a branch fell down. The worker, who was cutting the tree, was able to raise his arm to protect his head. Unfortunately, this did result in a broken arm. The main contractor investigated the incident to prevent such accidents from happening again, which was done with an incident investigation and a review meeting with all parties involved. The meeting was held with direct supervisors, workers, contractors' project management, and safety managers from both the contractor and the client. This resulted in a new procedure which was created in collaboration with the sub-contractors' employees. The new procedure would reduce the risks of loose branches falling down when a tree is felled.

4.2.3 Description Case ''Venetapark''

The second practical case investigated is called ''Venetapark''. The work being executed focussed on building a temporary road to ensure access to a small industry site, which otherwise would have been inaccessible during the length of the project. In a period of 8 to 9 weeks, this work had to be executed and finished. Delays in this work would result in delays to start succeeding tasks.

The work consisted of building an entire road, this includes preparation of the site, building the sewer, cables, making the foundation, building of the road and walkways, public lighting and the landscaping. The stretch of road is only a couple of hundred meters long, but it is a tight area. The tight schedule, number of tasks and consequently the number of people working on the small site created a high-risk area. The case is investigated to see how this high-risk task influences the safety performance of the people involved, since many construction projects are executed under similar circumstances.

4.3 Research methods

These cases are investigated by means of interviews, observations and document review. To understand the environment in which the cases are executed, the safety management system is investigated. For background information and the cases, it will be indicated which research methods were used, the limitations and the bias that were present during the research.

Background Information the ''Safety Management System''

Table 2 gives an overview of the research methods used for finding the background information, their characteristics, how results are obtained and the biases that are present. The results were obtained by document analysis and by conducting two interviews, the relevant protocols can be found in appendix A. The protocols which were used focused on the current status of safety management, methods, protocols, good and bad practices and what problems remain to be solved.

Table 2:
Overview research methods used in background investigation 'SMS'

RESEARCH METHODS	INTERVIEWS	DOCUMENT ANALYSIS
AMOUNT	• Safety expert (ID-001) • Safety expert (ID-002)	>40 documents & intranet pages
SELECTION CRITERIA	• Employed by BAM • Not directly involved in project • >20 years' experience	• Topic of safety procedures • Final version of the document
TOOLS FOR GENERATING RESULTS	• Interview Protocol • Open coding of transcript	• Document Protocol • IDEF0 Modelling
BIAS	• Small amount of interviewees leads to limited generalizability • Bias in questions	• Researcher influence on results • Missing documents • Reviewed by Safety Manager

The choice was made to model the results, due to the complexity and interrelations of the safety managements' procedures. Figure 10 illustrates the main model, displaying different processes that are used in managing safety in and around the project during the execution phase, detailed models of the individual processes can be found in Appendix E. These models help with gaining insight into the prescribed procedures, processes and rules that apply in the project. The models are made with the method: Integration DEFinition for Function (IDEF0). IDEF0 forms a tool that models '' the decisions, actions, and activities of a system in a structured graphical form'' (Kim & Jang, 2002, p. 123). The method helped to analyse and identify problem opportunities in complex and unclear systems, which is done by modelling the system based on inputs, controls, mechanisms and outputs (Kim & Jang, 2002).

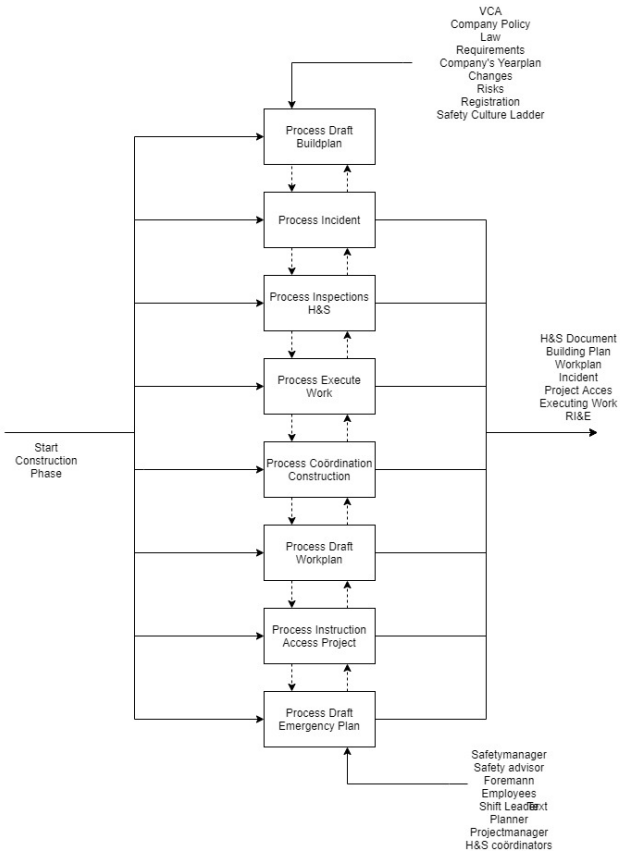


Figure 10: IDEF0 model showing main processes in the safety management system

CASES 'Bomenkap' and 'Venetapark'

Cases Bomenkap and Venetapark are both investigated by a combination of interviews and observations. Table 3 illustrates the characteristics and extra information about these research methods. The observations focussed on how work is executed, for example people's behaviour and compliance with procedures. The interviews were conducted with people knowledgeable about the case and were conducted is a private area for open and honest answers. More information about characteristics of the research methods can be found in Table 3 and the applicable research protocols can be found in appendix A. The protocols focussed on how employees experience safety, how they act on safety or unsafe situations, and the ability to work safely with the current safety procedures. This resulted in insight in improvement opportunities.

The case Venetapark only consisted of two interviews. Due to the Coronavirus lockdown further interviews were difficult to arrange. People experienced extra pressure for task completion, added work and changed work methods which made the people's willingness for doing interviews very low. The small number of interviews limits the data collection points and introduces a bias in the results obtained.

Table 3:
Overview research methods used case studies 'Bomenkap' and 'Venetapark'

RESEARCH METHODS	INTERVIEWS	OBSERVATIONS
Number For Case ''Bomenkap''	• Safety expert (ID-001) • Safety manager (ID-003) • Operator (ID-004) • Foreman (ID-005)	• 2 observation moments
Number For Case ''Venetapark''	• Foreman (ID-006) • Operator (ID-007)	• 2 observation moments
Selection Criteria	• Participants Involved in the case • Knowledgeable about task, procedures and practice	• Aspects observed as stated in the protocol • Protocol based on safety literature
Tools For Generating Results	• Interview Protocol • Semi-structured interview protocol • Open coding of transcript	• Memos written, aspects noted by following Protocol • Open coding of transcript
Bias	• Relative small amount of interviewees • Limited generalizability • Questions could influence interviewee • Researcher could influence interviewee • Follow-up questions or explanations could influence responses	• Researchers interpretation of observations • Change in observed behaviour due to presence observer • Data observed in Cross sectional design

Transcript to Results

The interviews and observations resulted in a series of transcripts. To reduce the large amount of data, a process of open coding has been executed. The choice was made to only execute open coding since the goal of this research is to find overarching themes and problems without too much detail. The process of open coding was focussed on finding aspects related to safety management, safety performance, safety problems and opportunities for improvement. The results obtained from the open coding is presented in the following section.

4.4 Results Case Studies: ''what goes wrong in practice''

This paragraph will present the results from the background investigation and the different cases, presented in the same order as above. First, the background information about the safety management system (4.3.1). Second, the results of the case 'Bomenkap' (section 4.3.2) and finally, the results from the case 'Venetapark' (section 4.3.3).

4.4.1 Results 'Safety Management System'

The safety management system can be divided into tasks executed on a company scale and ones that are executed on a project scale. The projects' safety procedures are presented in Figure 11, by application in the OSHA (2005) model.

The Safety Management System – Results document analysis

The investigation of the safety management system shows that during the last decade safety became more important in the organisation. Illustrated by the commitment of top management; 'Safety comes first, everyone should get home safely and every type of injury should be avoided' (Management BAM). Changes are implemented to create a better safety record, with growing attention towards changing behaviour instead of adding procedures.

The safety management system is tailored to each project within the company and therefore slight variations in procedures can be present. The safety management system is designed by the project's safety manager, who has designed the total system to their best knowledge to make it suitable for the project. This requires that the safety management system is tailored to meet requirements, specific environmental conditions and possibly wishes of the client.
The safety management system consists of a combination of documents, methods, instructions and procedures that should help with indicating and achieving safety. The IDEF0 models created (appendix E), show the total set of aspect incorporated in the safety management system, an overview of these aspects is presented in Figure 11. By analysing the models, problems in the safety management system were identified. The problems that were identified are that the workforce is hardly involved in the management of safety, only (safety) managers, planners or coordinators are involved in the preparation and planning. Additionally, there lacks a moment for review of the executed work, the experiences or new knowledge encountered is never reviewed.

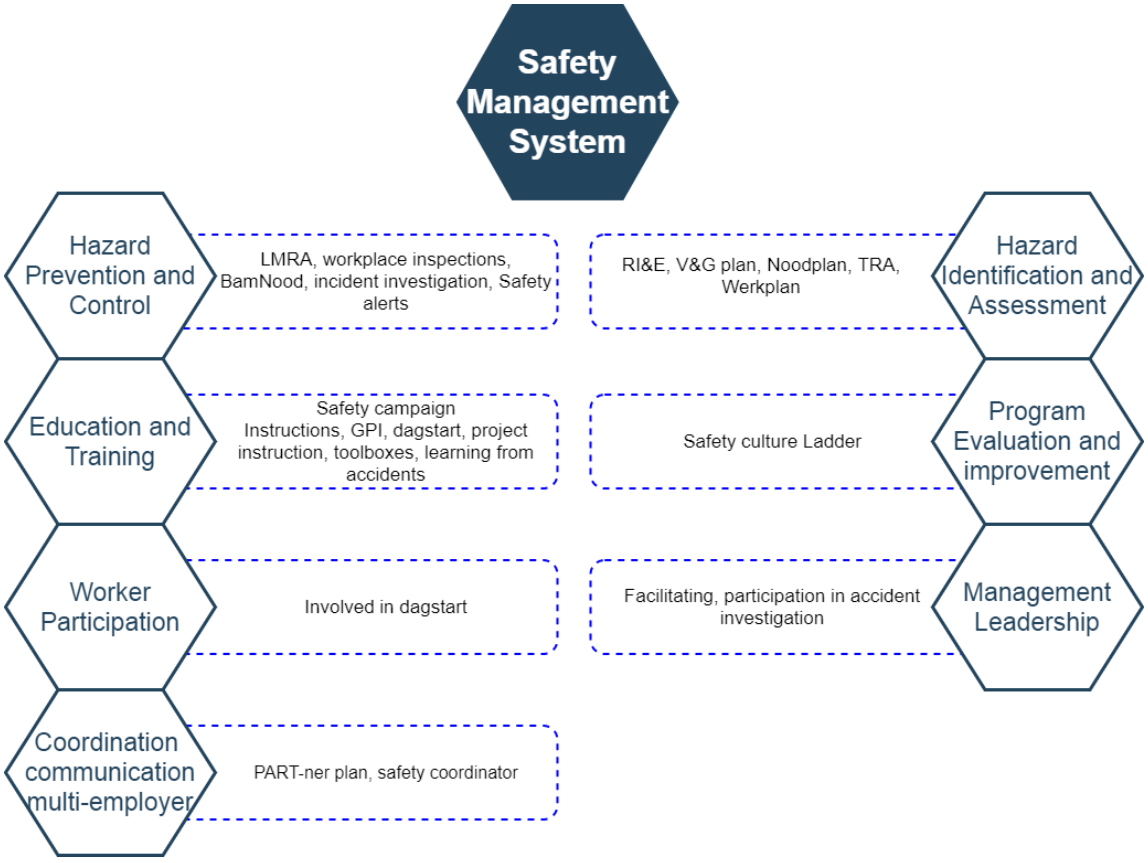


Figure 11: Implemented SMS procedures in case: project HOV 't Gooi (own illustration)

Results Interviews about SMS

Despite a negative attitude towards the system, interviewees indicated that major steps that have been taken in the last couple of years. Safety performance of the company and projects is improving. Their responses indicate that safety levels are improving, people are becoming more aware about safety and most procedures are better implemented. Despite the positive safety improvements, interview results show that safety managers see many improvement opportunities. The procedures in place are perceived as a document trail for certifications, instead of helping to achieve safety. Also, it is indicated that during execution they see a difference between the perceived use and the actual use of procedures. Despite this insight, they blame the executive staff, ''they fail to meet the required procedures'' (Quote ID-001).

A problem identified is that the system provides a general basis on which every project should build, but that the final level of safety management depends on the safety managers' efforts. ''Only implementing the provided procedures results in a low score on the safety ladder'' (Quote: ID-002), indicating that only legal requirements are met. The interviewee explained this as the result of a series of unhelpful targets and an unclear system. The goals itself do not help in improving safety, the goals are focussed on ticking off numbers of safety inspections and the number of inspections does not say anything about the usefulness of them.

Another problem that remains is that there is a mismatch between 'the needs of the execution' and the 'procedures and plan written'. Interview (Quote ID-002) showed opportunities in providing better safety education by focussing on aspects that are of interest to the people. Better focussed improvements can make large improvements to the safety behaviour of the workforce. Close collaboration with the client's project manager was indicated as another improvement opportunity because discussing and solving safety issues together brings understanding and better control over these issues. The interviewees state that this benefits projects since it creates a safety focus by both the client and contractor.

4.4.2 Results case ''Bomenkap''

In Table 4 an overview of the findings of the Bomenkap case can be found and in the following paragraphs explanations will be given to these results.

Table 4:
Summary results found in the case "Bomenkap', ordered from positive to negative

Summary Results Case ''Bomenkap''
Positive safety behaviour (awareness, safety discussions and looking out for each other)
Positive prevention measure developed by close collaboration process
Workers identify safety problems
Both client & contractor involved in the incident investigation
Failures in communication & resolving of identified safety problems
Presence of differences in safety (attitudes) between parties
Prepared safety paperwork (risks) not useful for workforce

Paperwork

The first finding is about the paperwork distributed to the workforce. The main contractor did the preparation of the work, identification of risks involved and distribution of instructions (general instructions, not on how to fell the trees themselves). These preparations have been communicated (written and verbal) with the sub-contractor. Safety education was given through verbal and online instructions about (project) risks. Based on the interviews, it was found that workers do not pay attention to workplans or project instructions. Risks were known based on their experience and the plans were too lengthy and not attractive. It was found that there is a mismatch between the office and what is needed during execution.

Awareness

A second finding is about employees' awareness. Observations showed that employees were aware of their surroundings, both for people around them and risks present. This showed in their behaviour and their responses when confronted with risks present during their work. It was found that risks were discussed before the start of the work and workers were actively looking out for their co-workers. One

instance was striking since an employee came to instruct the researcher about special certifications required for a particular part of the worksite. His reasoning was that he saw some people with orange coats, and he wanted us to be informed. This shows that among the employees, people are aware and watch out for each other. Which is a positive finding, showing that the workforce put attention towards working and acting safely.

Identify safety problem

The third finding showed that safety problems are actively identified, which was seen in the second observation. It was seen that worker try to identify safety issues; workers identified a risk that temporary steel road plates posed for cyclists. The cycle lane and the road came together on one point and because the steel plates can get slippery, they pose a slip risk for cyclists. This issue and the proposed solution were presented by the workers to the middle management, who dismissed the issue since solving it would harm production. The issue remained unsolved for some days until the safety manager overruled the middle management and the problem was solved within 30 minutes. This shows that people on the worksite see and recognise safety problems however, clear communication and acting on issues is lacking.

Incident

The final findings show differences in the behaviour of client and contractors, and the positive outcomes of collectively created improvements. During the interviews the earlier mentioned broken arm incident was discussed, and interviewees perceived the initial responses as sufficient. Work was immediately stopped on order of the sub- and main contractor. The main-contractors' manager immediately informed all parties and employees and regular updates were distributed. The client was only represented by its safety manager, indicating a difference in the attitude and commitment of the management of the parties.

Some interviewees were involved in the incident investigation. The results show that all prescribed procedures were followed and the employee was aware of the risks and took all prescribed precautions. The investigation showed that falling of dead branches was considered as part of the job by the sub-contractor's workers and they were wearing personal protective equipment as was the prescribed prevention measure. After the incident, the main contractor focussed on finding better prevention measures, and his safety manager helped to review procedures to lower the chance of the falling of dead wood. Close collaboration with the sub-contractor resulted in a new procedure which was to shake trees with heavy machinery. The interviewees state that the acceptance of this measure was high, as a result of the collaboration from all parties to come to this conclusion.

4.4.3 Results case ''Venetapark''

In Table 5 an overview of the findings of the Venetapark case can be found and in the following paragraphs explanations will be given to these results.

Table 5:
Summary results found in the case 'Venetapark'

Summary Results Case ''Venetapark''
Excessive documentation required
Risks not correctly documented
Education not focussed on the needs (or interests) of workforce

Documentation of procedures

During the Venetapark case, one of the inspections showed that most of the procedures specified by the company were not done in practice. For example, procedures as LMRA (last-minute risk analysis) and PART-ner plan (Planned approach riskfull tasks - plan). These procedures required documentation and it was mentioned by the foreman that he simply did not have the time to document all of them. Also, the people working outside do not have the time nor patience for writing these down. It was stressed that this does not mean that the safety procedures were not used, in practice they are done every day. With a cup of coffee, the tasks, risks and interactions are discussed before starting the work. Reporting the executed procedures is not in their interest which is perceived as a burden instead of helping the workers to work safely.

Risk not correctly documented

Another aspect mentioned was that the risk inventarisation and evaluation (RI&E) does not correctly reflect risks experienced during execution since the RI&E is based on standardized lists of risks that are present during certain activities. The workers explained that risks are discussed before starting their work, but that these are mostly based on their experience. The workers hinted at the fact that they do this kind of work on a daily basis and do not need someone to explain the things they already know and do. They also stated that the risks are not always correctly displaying reality. Different risks can be present or have priority and this is not correctly displayed in such plans.

Mismatch instructions

Similar frustrations were seen when the workers were asked about trainings. The training (education practices) executed consisted of toolboxes about topics relevant to the executed work. For example, before the placement of the sewer, the toolbox was already incorporated as an attachment in the workplan. The workers indicated that such standard education does not help them in their work. The information was already known and therefore not much attention was being put towards the instruction. The workers found that training can help them, but the current topics are not interesting to them. They like to have some input into the topics discussed in order to match these with their interests. With a motivated audience, the training could have more benefit in improving the safety knowledge of the workers.

4.5 Comparison of case Results

The results obtained show that there are multiple interesting safety aspects found, most of these aspect are perceived as negative. While there is only one positive aspects clearly mentioned. The mentioned (negative) aspects could form opportunities for improvement, therefore these will be further compared and discussed. Firstly, the perceived positive aspect is discussed. Second, the perceived negative aspects are presented and finally, some improvement aspects are identified.

Positive perceived: Safety Behaviour

In the cases, it is found that employees display positive safety behaviour. Audit reports show that safety behaviour and safety awareness has improved, and that safety is starting to become part of every day's life. This can be seen in that people are actively stimulated to report and discuss safety incidents, much time is spent on safety education and training and that the management is actively committed to safety. Workers show positive behaviour during work by making sure all bystanders are safe. This shows that the attention put towards the safety behaviour of workers is starting to pay off, this could be one of the indications that there is a start of a culture for safety in the organisation (Cooper & Philips, 2004).

Negative perceived: Differences safety attitudes

During work execution, it is seen that most employees see safety as an important element of their work, but that it is not their main priority during their work. There is a difference between own employees and employees of sub-contractors in the priority of safety and the acknowledgement of risks (Priemus & Ale, 2010). The main problem is acting on the risks, the workers should go from knowing to acting on a risk. Which is seen in the case 'Bomenkap' which was partly executed by a sub-contractor. The risk of falling branches was tolerated by the sub-contractor, while the main-contractor did not tolerate such risks. This shows a difference in safety attitudes between the different parties.

Differences in attitudes were also seen within the organisation of the main-contractor. In the case 'Bomenkap', a reported unsafe situation was dismissed by middle management. The production was more important than maintaining a safe situation for bystanders. In this situation, an unsafe situation was reported by the workforce, middle management dismissed it and never communicated it to the safety manager. This indicates there is a need for clearer communication channels and a safety culture where the boss accepts to hear bad news (Dekker, 2014).

Negative perceived: Safety Targets

The interviews and document review showed that one of the problems is the setting of safety targets by the company. While these are designed for creating safety, in practice they have the opposite effect. The targets are open for discussion, open for manipulation or encouraging behaviour which does not result in the safest situations. These targets focus on e.g. the required amount of safety inspections, their documentation or the number of educational moments. A higher number of these targets will not lead to better safety performance. The quality of the targets and the focus on needs will be a better guideline, as is indicated in the interviews (ID-001, ID-002, ID-003, ID-004, ID-006). From the interviews can be concluded the current targets do not help in achieving safety and that they only form a document trail and could lead to negative (fraudulent) behaviour.

Negative perceived: 'Right' Prescribed Procedures

Another perceived negative aspect found was that there are different views of the 'right' safety procedures. ''In most projects, the execution fails to meet the set procedures and plans, executive workers are often the problem in not meeting safety requirements'' (Quote: ID-001). This quote illustrates that the safety department sees their way as the right way, but in practice the procedures do not match the needs during executions. Mearns, Whitaker and Flin (2003) indicate that safety management systems create right documentation for certifications, but do not set the right procedures for ensuring safety during execution.

The workforce does have ideas and thoughts about safety procedures, but their experiences and knowledge do not lead to the development of procedures. By investigation of the safety management system, it has been found that workforce knowledge is not captured. Having a better understanding of the needs of the workforce can help to improve performance, procedures, preparation and training. The review of the procedures for felling trees (case 'Bomenkap') shows that the involvement of the workforce increased the acceptance and decreased resistance to new procedures.

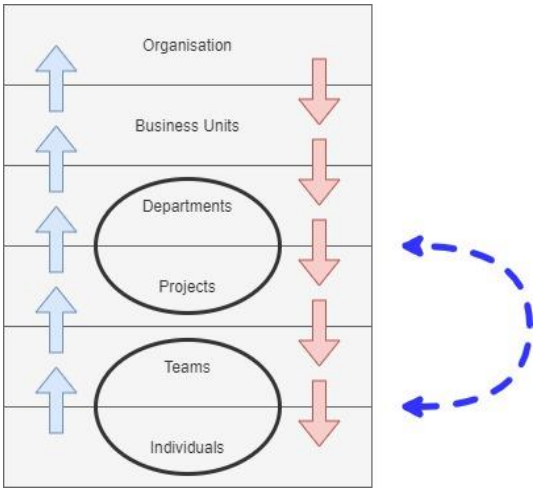


Figure 12: information flow in hierarchical model of organisation (based on Rasmussen, 1997)

Negative perceived: Management of safety

The last perceived negative point highlighted is the management of safety by high levels in the organisation. This is illustrated in Figure 12 (based on Rasmussen, 1997), where it can be seen how different levels of a company interact with each other.

The investigated cases show that the problem is that safety is managed at the higher levels (Departments and projects, or the blunt end), while there is not enough two-way interaction with the lower levels (Teams and Individuals, the sharp end[5]). Procedures, and in some cases provided resources, fail to meet the needs of execution. This is mentioned in different interviews (ID-001, ID-002, ID-005, ID-007). Interviewees indicate the need for more feedback in procedures, solutions and problems encountered. This is an aspect that is part of the root cause of some of the earlier identified problems such as procedures and safety targets.

Improvements

In addition to the positive and negative points, the results show opportunities for improvement. These are adapting safety management to the needs of the workforce, incorporating feedback in the management of safety and focusing on differences between parties. Workers have knowledge and experience that could help with improving safety in e.g. education, procedures and better solutions. An example of this is the new procedure developed after the broken arm incident. The new procedure was better suited and better accepted since it was created in collaborative (involvement of different parties and different employees) manner. Similar improvement opportunities are identified by scholars such as Dekker (2014) and Haavik et al. (2019).

4.6 Conclusion

As is presented in this chapter, there are multiple problems with the current safety management practices. The current practices mostly describe how work should be done safely, while not necessarily describe the best ways of actually achieving safety. This chapter is used to answer the sub-question 2:

> SQ2: How is safety management practically applied in construction environments?

In practical environments, safety management is executed by implementing safety management systems, which prescribe methods, procedures and instructions for work execution. These systems are based on standard models and are further refined by using experience and knowledge of the safety manager. In practice, this results in systems that are well documented, and provide documental trails when certification is required.

During work execution, multiple aspects came to light regarding the safety management system. In practice, the needs of the workforce do not suit the prescribed aspects in the safety management system. While employees' safety attitudes are positively experienced, there are multiple aspects perceived as negative, such as having differences in safety culture, setting bad safety targets, setting unsuitable prescribed procedures and only managing safety by high office functions. Many of these negatively perceived aspects originate from lacking a feedback mechanism that fail to capture the knowledge, needs and experience of the workforce.

Coordinating the workforce's needs and the prescribed safety procedures will require more feedback. Currently, this knowledge is not gathered nor acted upon. This is identified as an improvement opportunity because gathering and acting upon the workforce safety needs could have a major impact on safety performance. Another improvement opportunity shows the need for more safety collaboration between clients and contractors and between office and worksite personnel. The research shows that collaborations between parties could lead to new improved practices, which could lead to work being executed safer.

[5] At the sharp end: involved in the area of any activity where there is most difficulty, competition, danger (Collinsdictionairy)

Conclusion Phase 1: What to improve?

In chapter 3 and 4, the first two sub-questions are answered. It was found that both the literature investigation and the practical investigation show that there are opportunities for improving safety collaboration. Since these conclusions provide relative broad solutions, it is necessary to refine the solutions which will be further investigated. This section will provide further information about the solution by answering sub-question 3.

Literature shows that collaboratively managing safety is already investigated, but that many problems remain (Milch & Laumann, 2016). Most safety collaborations exist through appointing one safety management system and make all project parties adhere to that safety management system. However, this results in collaboration problems (Milch & Laumann, 2016). Nenonen and Vasara (2013) state that most of these problems would be prevented by co-operating and co-managing safety management practices. This is for construction projects an area which received little attention. As stated before, Hale (2001) investigated a case which tried to truly manage safety collectively. All parties were involved (client, contractors and sub-contractors) to discuss and manage safety together. This was done by creating a separate organisation, tasked with improving safety performance. In Hale's investigation, attention was put towards the mandate, tasks, and while not referred to by name, the preconditions and composition of the separate organisation.

In consultation with the research supervisors, the desire of all parties to further investigate the safety collaboration between public and private parties was expressed, which is in line with the ambition of the graduating company (BAM Infra B.V.). The gap present in safety collaboration literature sparked the interest to contribute to this field of knowledge. Therefore, the rest of the research will further focus on the characteristics of a collective safety management organisation in a public-private construction environment.
This makes it possible to answer the third sub-question:

> SQ3: Which improvement opportunity should be further investigated for application in a construction environment?

It is identified that safety collaboration could be a valuable improvement opportunity for current safety levels. Based on literature, a separate organisation tasked with managing safety could be a promising possibility. The application of such a safety organisation requires more research into its characteristics. As in the research of Hale (2001), the second phase of this research will focus on the preconditions, composition, mandate and tasks of the safety organisation.

PHASE 2 INVESTIGATION IMPROVEMENT OPPORTUNITY

Methods for Shaping Safety Organisation
&
Results

5. Methods for Shaping Safety Organisation

As mentioned earlier, the case studies are approached as a preliminary investigation and used as a starting point for the rest of this research. This chapter will explain the goal of the second part of the research (section 5.1), its research methods (section 5.2) and how the data has been reduced to the final results (section 5.3).

5.1 Research goal

As identified in the previous chapter a promising safety improvement opportunity is to collectively manage safety in projects, which would entail a collaboration including contractors and cliental parties. It is identified that this could be realised in the form of a collective safety organisation. However, as stated in the previous chapter, this requires more knowledge about the composition, tasks, mandate and preconditions of this safety organisation. The purpose of this second part of the study is to obtain this information and determine a rough outline of the organisations' characteristics.

Because of the limited time and space, this study will not focus on the long-term effects of such organisations. Instead, it will focus on the aspects required for designing and implementing such an organisation.

5.2 Research method and selection respondents

The investigation is executed by conducting an expert panel and a series of interviews. The combination of these research methods will be used to help design the characteristics of the safety collaboration. This section explains the research methods, selection criteria, respondent criteria and biases present in the research. Section 5.2.1 focusses on the interviews and section 5.2.2 focusses on the expert panel.

5.2.1 Interviews

For this part of the research, a total of 10 interviews is conducted. Table 6 provides an overview of the interviewees and their characteristics. Interviewees have been selected based on their safety expertise, experience >10 years, variety of backgrounds within the construction industry and on their different representations of public/private organisations. This resulted in interviewees who represent a variety of views and backgrounds in the industry and a balance in contractor and client parties as well as in private and public perspectives.

Table 6 presents the interviewees, their function, experience in client/contractor organisations and their years of experience. Interviewees' names are not presented to sustain the anonymity of the interviewees. The same holds for the company in which they currently work because this could indirectly disclose their identity.

Table 6:
Overview of interviewees for design safety organisation

INTERVIEW	FUNCTION	COMPANY	PRIVATE / PUBLIC EXPERIENCE	YEARS OF EXPERIENCE	METHOD
ID-101	Safety manager	Consultant A	Public	>20 Years	Face-to-face
ID-102	Safety Advisor	Consultant B	Both	>15 Years	Face-to-face
ID-103	Safety Advisor	Consultant C	Public	>20 Years	Face-to-Face
ID-104	Safety Advisor	Contractor A	Private	>25 Years	Face-to-Face
ID-105	Safety Coordinator	Contractor B	Private	>14 Years	Face-to-Face
ID-106	Safety Advisor	Contractor C	Private	>25 Years	Face-to-Face
ID-107	Safety Manager	Consultant D	Private	>10 Years	Skype
ID-108	Safety Manager	Consultant E	Both	>25 Years	Skype
ID-109	Safety Advisor	Consultant F	Both	>25 Years	Skype
ID-110	Project Manager	Contractor A	Private	>10 Years	Face-to-face

The interviews have been conducted as semi-structured interviews with an interview protocol as a starting point (Appendix B). The questions were pointed towards finding the characteristics of collaborative safety management. In addition, when new interesting topics came to light, extra questions could be asked to investigate these topics. Despite the semi-structured approach, there have been differences in the manner of conducting these interviews. Some interviews were face-to-face while others were via Skype due to the earlier mentioned Corona crisis. The interviews have been transcribed and coded (open and axial) to create the final set of results. After conducting the last set of interviews, it turned out that the results obtained were similar to earlier interviews, showing that an information saturation point has been reached (Saunders et al., 2017).

Bias

The circumstances during the research (Corona virus lockdown) made it impossible to conduct all interviews in the same manner, which increased the chance of biases being present. This is because different interview conditions could change the behaviour and responses of the interviewees (Salazar, 1990). This bias is assumed to be minimal because after the comparison between the two interview methods, the behaviour and responses did not seem out of the ordinary and results were comparable with results gathered in face-to-face interviews.

Other bias present in this research method could be due to the questions themselves or the way the questions have been asked (Salazar, 1990). The interviews are conducted by a researcher who is not experienced in conducting interviewees and therefore the possibility exists that the researcher introduced biases. This risk is reduced as much as possible by using an interview protocol with questions that are similar between interviews. Also, bias could be present by people who did not felt comfortable to answer some questions. This risk is addressed by conducting interviews in neutral places (e.g. closed-off offices), the neutral nature of researcher (people are treated as anonymous respondents) and starting interviews with general questions that are easy to answer.

5.2.2 Expert Panel

The second research method used in this part of the research is an expert panel which is a special composition in a feedback panel. This research method focusses on a ‘’group of people who will talk about a clearly defined issue’’ (Sekaran & Bougie, 2013, p. 122). An expert panel is similar to a feedback group, only the panel consists of people that have expert knowledge and opinions. The selection of people should represent a wide range of knowledge and opinions that are relevant for the specific topic.

The selection of participants for the expert panel should include a variety of opinions and views. The selected participants are from the project HOV in ‘t Gooi and the members of the panel represented different functions, expertise and parties involved in the project. In Table 7, an overview of the composition of the expert panel is provided. This composition represents expertise in safety management, project management and day-to-day execution. With this panel, there is a fertile basis for a discussion about how the proposed safety collaboration would look like.

Table 7:
Composition of the expert panel

EXPERT PANEL	ORGANISATION	FUNCTION
	Main Contractor	Project Manager
	Main Contractor	Safety Manager
	Client	Project Manager
	Client	Safety Advisor
	Independent	Safety Expert
	Contractor	Project Manager

The expert panel meeting had an organised structure and a pre-determined set of aspects that needed to be discussed. The meeting was led by a moderator who steered the discussions and kept respondents focused on the topic. The moderator was not the same person as the researcher to keep the researcher free for observation and transcribing the discussions. The moderator was not heavily involved in safety or had much experience in it. This helped in preventing bias caused by his/her opinion or by steering the discussion.

The data obtained from this research method is collected by observation of the discussions and opinions voiced during the meeting. By means of a protocol, the aspects mentioned were written down. The protocol (appendix C) describes aspects that could be discussed and which should be written down. Afterwards, the initial notes were written down in a coherent story. To ensure the completeness of this transcript, it was checked by one of the participants of the expert meeting. Feedback was provided and processed to create the final transcript. This transcript was coded to create the final set of results.

There is an opportunity for bias in the transcript of the meeting because only one researcher observed the meeting. This creates the opportunity for the researcher's selection of the topics written down but this is risk is mostly prevented by having the transcript being checked by one of the participants. The selection of members who all were directly or indirectly involved in the case HOV in 't Gooi will have a bias towards the specific project environment but by comparing results with results from the other research method (interviews), this bias is lowered.

5.3 Analysing results - Axial Coding

Transcripts containing results (from interviews and expert panel) were made and for further data reduction these transcripts have been coded. Firstly, the data was coded with an open approach to investigate the content. Open coding is based on researchers' insight, experience and knowledge (Sekaran & Bougie, 2013). The open coding executed for this research focussed on aspects such as; safety, collaboration, tasks, procedures, rules and conditions.

The second round of coding, axial coding, is executed to ensure reliability and comparability in the aspects mentioned. Axial coding is typically used in later analysis stages to redefine and differentiate concepts, by using deductive procedures the data is reduced to a series of concepts (Flick, Kardoff, Steinke & Jenner, 2004). Axial coding is coding executed with a protocol (appendix D), which describes the different codes and what these entail. The protocol focusses on the previous identified aspects (preconditions, mandate, composition and task), which are further refined by using knowledge from safety collaboration and partnering literature. The overview of the codes is presented in Tables 8, 9, 10 and 11, with the first column stating the axial codes and the second column providing their descriptions. These short descriptions are stated to explain the codes, further descriptions can be found in appendix D.

In order to increase the reliability, the coding process is checked by a second researcher who did a spot check of the coding process. It was checked if the codes corresponded with the transcript and if the codes contained all information. While the second researcher did not execute a complete second coding process, the check executed does improve the reliability of the coding process.

Table 8:
Explanation axial codes used for identifying preconditions

PRECONDITIONS AXIAL CODING	DESCRIPTIONS
Need Open Culture	Parties are open about and share information, issues, problems and solutions
Client Leading	The client should start with expressing safety ambitions, parties will follow this lead
Commitment Parties	Parties will need to commit to organisation & understanding what participation requires
Resources Required	Participation in safety organisation requires time, money and people
Difference Knowledge Levels	Differences in parties' safety knowledge & experience can be present
Good Relation	Need good relation between parties, with trust and acceptance
Upkeep Relation	Continuously work on the relation between parties, relations will deteriorate
Independent Organisation	No party owns or can solely control safety organisation

Table 9:
Explanation axial codes used for identifying Composition

COMPOSITION AXIAL CODING	DESCRIPTIONS
Safety Knowledgeable People	Compositions of Safety managers; Safety coordinators; Safety experts
All Parties Involved	All project parties should contribute and be able to be part of meetings
Workforce Involvement	Involvement of the workforce, by obtaining their expertise & knowledge for usage in collective safety organisation

Table 10:
Explanation axial codes used for identifying Mandate

MANDATE AXIAL CODING	DESCRIPTIONS
Advising Role	The organisation will give advice to the participating parties
No Legal Agreement	Mandate not based on contract, based on parties' shared agreement for participation
Commitment Management	Parties' leadership needs to commit, to ensure internal compliance with the advice of the safety organisation.
Integral Safety Plan	Collectively written document describing how, why, when, who, tasks & responsibilities.
Responsibility Issues	Can't delegate responsibility to central level, it should remain with party who is able to or who should bear it.
Regular Meeting	Requires regular meetings
No Control Work Others	Parties can't control work executed by others

Table 11:
Explanation axial codes used for identifying Tasks

TASK AXIAL CODING	DESCRIPTIONS
Vision & Goals	Centrally create safety goals, execute these and review their progress.
Education	Centrally focus on education & instructions, all workers need same knowledge
Central Discussion Safety	Parties should discuss safety; problems, ideas, risks and solutions
Implement Ideas Workforce	Centrally discuss and implement ideas originating from the workforce
Safety Communication	Centrally communicate safety with parties or employees
Rewarding	Co-ordination of safety rewards given in the project.
Incident Handling	Centrally document, investigate & distribute aspects found during incidents.
Document Safety Knowledge	Centrally capture safety information found in meetings & from experiences
Inspection	Co-ordination of safety inspection between/with parties

6. The Ideal Safety Organisation

The focus of this chapter is to discuss the general outline of the safety organisation. Which is done by focussing on preconditions, composition, mandate and task of this organisation. Literature indicated that a safety organisation is based on these characteristics, the focus of this research was to identify these aspects for application in a construction environment. The results obtained will help with answering the sub-questions 4, 5, 6 and 7. This chapter discusses the results obtained from the Interviews (section 6.1), the results from the expert panel (section 6.2), the comparison of the results from the two research methods (section 6.3) and ends with a conclusion (section 6.4).

6.1 Results Interviews

The interview results are presented by topic: preconditions, compositions, mandate and tasks.

Preconditions

In the interviews, the preconditions for the safety organisation have been investigated and Table 12 displays the preconditions found. The results are mainly obtained by directly questioning the interviewees about preconditions but there are also preconditions mentioned during questions not aimed towards finding these preconditions. Experts indicated the preconditions as supporting for aspects relating to mandate or tasks. For example, one of the identified tasks is to discuss safety problems and aspects. The experts indicated that this does require an open culture between the parties.

Table 12:
Responses interviewees on preconditions

AXIAL CODING	MENTIONED BY:
Need Open Culture	ID-102, ID-103, ID-104, ID-105, ID-106, ID-108, ID-109, ID-110
Client Leading	ID-101, ID-102, ID-103, ID-106, ID-110
Commitment Parties	ID-103, ID-106, ID-108, ID-110
Resources Required	ID-102, ID-103, ID-105, ID-106, ID-108, ID-109, ID-110
Difference Knowledge Level	ID-105, ID-106, ID-110
Good Relation	ID-102, ID-103, ID-104, ID-105, ID-106, ID-108, ID-109
Upkeep Relation	ID-104, ID-106, ID-108

Composition

Besides the preconditions needed for a collaborative safety organisation, the results give insight into the possible composition of such an organisation. The safety experts had little doubt about the composition and an uniform set of responses was received. Table 13 displays these results. The responses suggest a collaboration between parties' safety managers in which they collectively discuss safety and help each other. This will require that that all project parties should be involved during these meetings, on the condition that parties are employed for longer periods of time.

The interviewees also mentioned the opportunity for involving the executing workers because their expertise and knowledge can be helpful in solving safety problems. Employees have insight into aspects that go wrong, could be improved or can be done differently while the safety manager does not necessarily know about these aspects. How these employees should be involved was prone to more discussion. Responses ranged from a separate meeting between workers to representatives being directly involved in the meeting between the safety managers.

Table 13:
Responses interviewees on Composition

AXIAL CODING	MENTIONED BY:
Safety Knowledgeable People	ID-101 ID-102, ID-103, ID-104, ID-105, ID-106, ID-107, ID-108, ID-109
All Parties Involved	ID-102, ID-105, ID-106, ID-107, ID-108, ID-109
Workforce Involvement	ID-102, ID-103, ID-104, ID-105, ID-106, ID-107, ID-108, ID-109

Mandate

The third topic identified is about the mandate of the safety organisation. Not all respondents found themselves knowledgeable on contracts or required legal obligations to give a definitive answer on the organisations' mandate, while others mainly saw problems with implementing rules and practices into other organisations. The consensus found was that changing the legal responsibilities (required by law) in organisations should be avoided because it creates more problems than it would solve.

The results obtained (Table 14) show that the safety organisation should mainly have an advisory role without any power to enforce their recommendations. The organisation's support should instead originate from the commitment of the parties' management, they can create support in their own organisation for the safety organisations' advices. The general support for the safety organisation should not be enforced by a legal agreement. The results show that experts find that the participation, involvement and cooperation should be created by the shared commitment of the parties. Which could be in the form of an integral safety plan consisting of rules, responsibilities, obligations and some special additions that describe that parties will not have control over others workforce, the regularity of meetings and that responsibilities should remain with parties who can bear them.

Table 14:
Responses interviewees on Mandate

AXIAL CODING	MENTIONED BY:
Advising Role	ID-102, ID-103, ID-104, ID-106, ID-108, ID-109
No Legal Agreement	ID-103, ID-106, ID-108, ID-110
Commitment Management	ID-102, ID-104, ID-110
Integral Safety Plan	ID-102, ID-104, ID-106, ID-109
- **No Control Work Others**	ID-104, ID-107
- **Responsibility Issues**	ID-102, ID-106, ID-109
- **Regular Meeting**	ID-103, ID-104, ID-106
- **Tasks, Obligation & Responsibilities**	ID-102, ID-104, ID-105, ID-106, ID-109

Tasks

Collecting answers for the final characteristic, the tasks of the safety organisation, was one of the aspects that most safety experts felt most comfortable with. This was seen in their ease in coming up with answers and in the number of aspects mentioned between and in the interviews (Table 15). Differences in answers between the interviewees can be seen, which can be explained since some safety experts had a different view of the purpose of the safety collaboration. Some viewed the purpose of this organisation as a discussion forum for helping others and yourself by discussing safety. Other viewed the tasks of the safety organisation as centrally handle safety tasks which are normally done by individual companies. One of the aspects that nearly all interviewees stated was that this organisation should facilitate the possibility of a central safety discussion, educational activities and creating a shared vision and goal(s).

Table 15:
Responses interviewees on Tasks

AXIAL CODING	MENTIONED BY:
Vision & Goals	ID-101, ID-102, ID-103, ID-105, ID-106, ID-108, ID-109, ID-110
Education	ID-101, ID-104, ID-105, ID-106, ID-107, ID-108, ID-109, ID-110
Central Discussion Safety	ID-102, ID-103, ID-104, ID-105, ID-106, ID-108, ID-109, ID-110
Safety Communication	ID-102, ID-104, ID-105, ID-106, ID-107, ID-108, ID-109
Implement Ideas Workforce	ID-101, ID-104, ID-105, ID-107, ID-108, ID-109
Rewards	ID-102, ID-107, ID-109, ID-110
Document Of Safety Knowledge	ID-101, ID-103, ID-104, ID-106
Inspections	ID-101, ID-102, ID-109, ID-110
Incident Handling	ID-101, ID-108

6.2 Results Expert Panel

The experts discussed that safety is demanded by: ARBO, VCA, ISO certifications (ISO9001, iso18001), the safety culture ladder and the ambition level of a company. The legal responsibilities can best remain with the companies themselves while the ambition and safety culture ladder aspects can best be executed by the new safety organisation. Further discussions led to multiple characteristics of the safety organisation, presented in Table 16.

Table 16:
Results obtained from expert panel

TASKS	COMPOSITION	MANDATE	PRECONDITIONS
Central discussion safety	Safety knowledgeable people	Commitment Management	Independent of parties
Central incident handling	All parties involved	Advising role	Commitment parties
Central communication	Workforce Involvement	Responsibility issues	Need Open Culture
Implement ideas workforce	Implement ideas workforce	Tasks, Obligation, Responsibilities	
Rewards		Integral safety plan	
Inspections			
Education			

Preconditions

The members of the expert panel quickly agreed that in order for good functioning, the safety organisation should be independent of any organisation. This requires that all parties contribute evenly and that all parties need to be committed to the safety organisation. Ensuring their commitment will be a key factor for successful application and especially for the long-term existence of the organisation. For successful interventions and discussions, there is a need for having knowledge of the current situations and this requires parties to be open about their problems and needs.

Composition

The safety managers of the parties are seen as the members of the safety organisation, since these people are frequently on the project and have safety knowledge. While these people would have much knowledge and experience, they do not know everything. Therefore, the respondents indicated that a response panel should be created, consisting of workforce's representatives from different project organisations. The panel's function would be to gather initiatives, ideas and improvement opportunities.

Mandate

The members of the expert panel decided that the safety organisation should have an advisory role since the tasks they will execute result from an ambition presented by the parties. As discussed before, the focus should lay on tasks that are not legally required and therefore the conclusion was that this organisation should not have the power to enforce the advice given. To ensure that the advices will be taken seriously, it was discussed that there is need for the support of the management of the parties. This is needed to ensure advices are implemented in the participating organisations.

In addition, the experts mentioned that an integral safety plan should be written. This should be a document with the description of how the parties will collaborate as well as the tasks, obligations, responsibilities, and the commitment that should remain in their own organisations.

Tasks

Experts indicated the safety organisations' focus should lie on the safety culture ladder and the ambition which are tasks that focus on building a safety culture. This is often done by education, empowering of employees and creating understanding of the importance of safety during all tasks (Hudson, 2007). No standard set of tools exist to create a safety culture. Therefore, the experts proposed a series of tasks that should help.

For example, incident registration and investigation, safety communication, safety education and safety rewards. The experts indicated that collective coordination of these tasks will help in creating 'safety importance' in all parties. Problems, changes, improvements, solutions and additions should be regularly and centrally discussed, which requires regular meetings.

One expert voiced the concern of the workforce which was that the workers experience many safety inspections of different parties involved. The experts discussed to coordinate inspections between the parties, which should be a task executed by the safety organisation. The experts found that implementing similar ideas of the workforce are important to improve safety management, such safety improvement opportunities are aspects which are actively sought in Safety-II methodology (Dekker, 2014). The ideas of the workforce could be further discussed and implemented by the safety managers.

6.3 Comparison Results

The previous section displayed the results of the two different data collection methods and this section will compare them. This will be done by following the same topics as before: preconditions, composition, mandate and tasks.

6.3.1 Preconditions

The preconditions investigated in both methods resulted in some similar and some different outcomes (Table 17). Both methods found similar results in the need for an open culture and the commitment of the different parties to the new safety organisation. Both data sources suggest that these will be of importance to the organisation to open and freely discuss topics. Meaning that every idea or topic is accepted, confidentially is assured, a high tolerance for faults exists and no judgement is present.

Table 17:
Comparison precondition results interviews and expert panel

ASPECTS	INTERVIEWS	EXPERT PANEL
Need Open Culture	✓	✓
Client Leading	✓	
Commitment Parties	✓	✓
Resources Required	✓	
Difference Knowledge Level	✓	
Good Relation	✓	
Upkeep Relation	✓	

The interviews resulted in more preconditions that will apply. The majority of respondents indicate aspects such as the leading role of the client, the required resources and the need for good relations. The expert panel added that the organisation should be independent. It should not be owned or lead by one party but by all parties together. From a small number of interview other preconditions have been identified such as the differences in knowledge and experience and the need for maintaining the relations between parties. None of these aspects have been found during the expert panel which could result from the frame of reference of the participating members. They are focussed on their project environment, with existing internal politics and social relations. These conditions could explain why the experts did not mention these preconditions.

The final conclusion is presented in Figure 13. Both research methods mostly identified social aspects as preconditions, indicating that there should be much attention towards these social aspects. As some interviews indicate; relations, attitudes and behaviour will make or break the success of the organisation, these preconditions will therefore play an important role during the lifetime of the safety organisation.

Figure 13: Final results Preconditions (own illustration)

6.3.2 Composition

The results from both data sources indicate that the safety organisation should consist of a safety meeting and a response panel, Table 18. These two groups should help and support each other.

Table 18:
Comparison composition results interviews and expert panel

ASPECTS	INTERVIEWS	EXPERT PANEL
Safety Knowledgeable People	✓	✓
Parties Involved	✓	✓
Workforce Involvement	✓	✓
- **Separate Meeting**	✓	✓
- **Representatives Involved In Central Meeting**	✓	

Safety meeting

As can be seen in Table 18, both methods found similar results according to the composition of the safety organisation. All parties should be able to participate in the safety organisation. However, this was under the condition that the party was involved in the project for longer stretches of time.

The safety organisation should consist of project parties' representatives who are knowledgeable about safety. Results from both data sources indicate that safety managers are best suited to participate in the safety meeting because the participants need to have the know-what and know-how of safety management. Interviews indicated that when parties lack a safety manager, their participant could have another function such as, project manager, foreman or project coordinator. These persons should have the knowledge to fulfil this role and need to have both safety and practical (execution) knowledge. The meeting between the safety managers (or replacements) would entail the main body of the safety organisation, and execute the most of the safety organisations' tasks.

Response Panel

The involvement of the workforce was mentioned by both data sources. It was indicated by almost every interviewee as a useful source of information and ideas. While there was agreement over their usefulness, the manner of involvement created more discussions. Some respondents proposed a separate response panel consisting of workforce representatives. Others made the case for a couple of workforce representatives being part of the safety meeting and inviting additional workforce employees to participate in their meeting to talk about a specific topic. In the expert panel, a combination of these two approaches for workforce involvement was discussed. Proposed was to have a separate response group and have representatives of this group to join the safety meeting to present and discuss their points of attention.

Figure 14: Final results Composition (own illustration)

The response panel's purpose is two sided, on the one hand, it acts as an idea generator for aspects that occur during execution and on the other hand, it acts as a sounding board for the safety managers. The response panel should bring up ideas, initiatives, problems, improvements or any irritations that occurred during work execution. The panel also should review the ideas, proposals and plans of the safety managers. Their experience and knowledge of executing work in construction projects will play an important role in actually improving safety practices. Their feedback should be leading in designing new improved safety practices. The results are summarized in Figure 14.

6.3.3 Mandate

Every respondent in the expert panel and most interview respondents stated that it would be better to remain at an advisory role for the safety organisation. The universal opinion was that creating a legal basis for the organisation would create more problems than that it would help (Table 19). A legal basis would transfer legally required safety responsibilities to a project level. They see the safety organisation to help the project parties, not dictating how it should be done.

Table 19:
Comparison mandate results interviews and expert panel

ASPECTS	INTERVIEWS	EXPERT PANEL
Advising Role	✓	✓
No Legal Agreement	✓	
Commitment Management	✓	✓
Integral Safety Plan	✓	✓
- **No Control Work Others**	✓	
- **Responsibility Issues**	✓	
- **Regular Meeting**	✓	
- **Tasks, Obligation, Responsibilities**	✓	✓

The advising role of the safety organisation should be supported by the participating parties. The results of the interviews indicate that for participation no contract should be signed. Instead, participation should be based on a shared agreement by the parties and their management. To ensure that the advices of the safety organisation are taken seriously, there is a need for the support of the management. The management's commitment should entail that parties will do what is needed to ensure that the visions, advices and improvements of the safety organisation will be implemented in their own organisation.

There should not be a legal contract, but some documentation is required. Results from both research methods show that documentation should be in the form of an integral safety plan and that this document should be co-written by the participating parties. The final document should entail the relations and agreements on which the collaboration is built with attention to tasks, obligations and responsibilities. The content of this document should contain how the collaboration will be structured. In the interviews additional aspects for this were identified. Aspects that could be included are scheduling regular meetings, stating that parties have no control over the work of others and finally that parties cannot shift responsibilities to others who cannot bear them. Figure 15 displays the final conclusion made about the mandate of the safety organisation.

Figure 15: Final results Mandate (own illustration)

6.3.4 Tasks

The tasks that should be executed by the safety organisation have also been found by using the two research methods and the results are summarized in Table 20. There is agreement about the tasks of the safety organisation, consisting of safety education, central safety discussions, central safety communication, and implementation of ideas from the workforce. From this set of aspects, most safety tasks are normally executed on a central level except for the implementation of workforce feedback, which is an aspect that relates to the new Safety-II methodology.

Table 20:
Comparison tasks results interviews and expert panel

ASPECTS	INTERVIEWS	EXPERT PANEL
Vision & Goals	✓	
Education	✓	✓
Central Discussion Safety	✓	✓
Safety Communication	✓	✓
Implement Ideas Workforce	✓	✓
Rewards	✓	
Document Of Safety Knowledge	✓	
Inspections	✓	✓
Incident Handling	✓	✓

There was also some agreement about coordination of inspections and shared handling of incidents. While these aspects were mentioned in both research methods, just under half of the respondents mentioned these aspects during the interviews. Aspects which were only mentioned in the interviews are vision and goals, safety rewards and documentation of knowledge. This does not mean that these would not be of benefit when executed by the safety organisation, these tasks can be centrally executed when parties choose for doing them.

The last point in the task category is that most interviewees indicate that forcing a predetermined set of tasks could create resistance. A better solution is to provide a list of possible tasks. From this list, the parties should collectively choose what they will do centrally and what they will keep within their own companies. Certain tasks are highly recommended to implement while others are optional, as shown in Figure 16. Based on the high amount of responses and being mentioned in both data sources the following tasks are marked as highly recommended for implementation; safety education, central safety discussions, central safety communication, and implementation of ideas from the workforce.

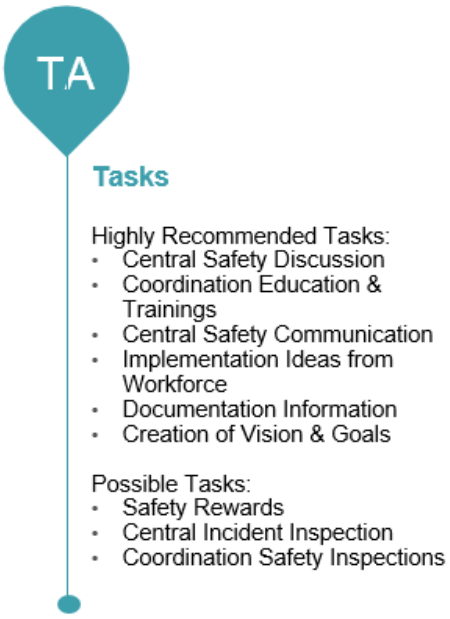


Figure 16: Final results Tasks (own illustration)

The tasks that are mentioned less, are presented as tasks that can be implemented in the safety organisation. Examples are safety rewards, central safety inspection and coordination of safety inspections. The results support these tasks to a lesser degree, therefore these tasks are indicated as tasks that could be implemented. This could be the case when parties participating in the safety organisation, all agree that these would create a benefit when executed by the safety organisation.

6.4 Conclusions

After discussing and comparing the results, this section will present the answers to the different sub-questions raised in section 1.4. With the knowledge and results gathered (see Figure 17) it will be possible to answer sub-questions 4, 5, 6 and 7. These questions focussed on the preconditions, composition, mandate and tasks of the safety organisation. The following sections will discuss the answers to the sub-questions that focussed on the collaborative safety organisation.

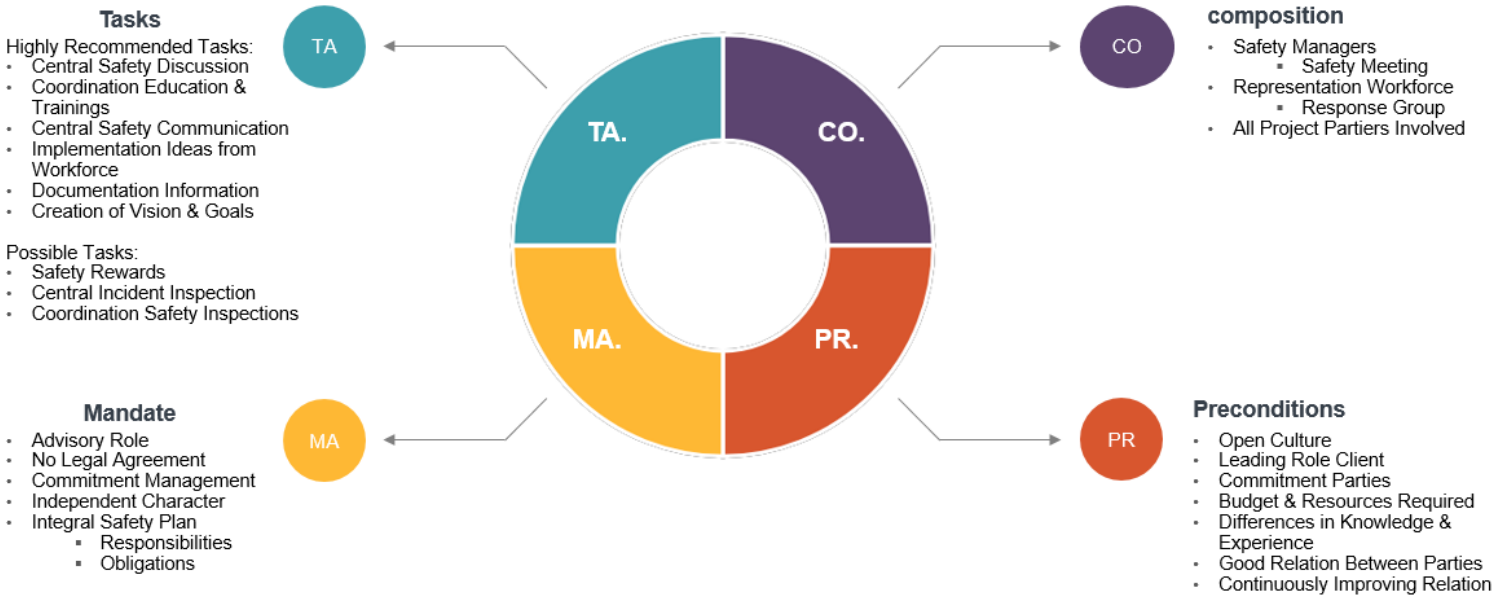


Figure 17: Illustration results Safety Organisation (own illustration)

> *SQ4: What are the preconditions needed for the public-private safety organisation?*

Different preconditions apply in a public – private safety collaborations. As found, these are mainly focused on ensuring social interactions. The social aspects identified are the required commitment of the different parties, the need for an open culture, the leading role of the client, the need for good relations between parties and the maintenance of relations between parties. These social aspects should be supported by ensuring that enough resources are supplied towards the use in and around the organisation and making sure that no party has full control or power over the shared safety organisation.

These preconditions are of importance to the final success of the safety organisation. Especially, attitudes, behaviour and relations will be of importance for successful collaborations. These aspects will have to be maintained during the lifetime of the safety organisation, and are expected to be of importance to the success of the safety organisation.

> *SQ5: Who should be included in the public-private safety organisation?*

All parties that play a significant role in the project should be included in the safety organisation, both from the client(s) side(s) and from the contractor(s) side(s). The safety organisation will be formed by representatives of these parties in the form of a response panel and a safety meeting. The safety meeting will consist of parties' representatives with safety-related functions such as safety managers. Not all parties will have a permanent safety manager employed, therefore other safety knowledgeable people can take their place.

This safety organisation will be supported by a response panel, consisting of diverse workforce representatives. Their function will be twofold, on the one hand, they act as an idea generator for aspects that occur during execution and on the other hand they act as a sounding board for the safety managers. They should bring up ideas, improvements, adaptations or bring up their work-related irritations that can be used to improve safety practices and which can further be discussed in the safety meeting. Preferably, a representative of the response panel will also take part in the safety meeting, to ease communication and transparency.

> *SQ6: What should be the mandate of the public-private safety organisation?*

The public-private safety collaboration should have a clearly explained mandate to secure their position between the participating organisations. The safety organisation can best have an advisory role since having a legal basis will result in responsibility problems. This advisory role should be supported by commitment of different managers. These aspects have to be incorporated in a collectively written integral safety plan, collectively writing this plan could help with creating acceptance among the involved parties. The integral safety plan should contain tasks, responsibilities and obligations. Additionally, some aspects that should gain extra attention in the plan are regular meetings, the statement that no party will have control over other parties' workforce and the prevention of shifting responsibilities between parties with advices given. The final integral safety plan should form the basis on which the collaboration is built.

> *SQ7: Which tasks should be performed by the public-private safety organisation? Which tasks should be carried out by others?*

The tasks that the safety organisation should execute cannot be prescribed since forcing a predetermined set of tasks could create resistance. Instead, parties should collectively choose what tasks will be executed in the collaboration and what tasks remain to be executed on a company level.

Certain tasks are highly recommended to implement centrally. These are for example, a central safety discussion, creation of vision and goals, central safety communication, safety education, safety knowledge documentation and the implementation of ideas from the workforce. Ideally, these aspects should form the basis of the organisation and additional tasks could be centrally executed when parties recognize these as suitable additions. Safety rewards, coordination of safety inspections and central incident handling are aspects that could be executed on a central level, if parties find these suitable additions for their specific project environment.

The participating organisations should keep legally required aspects in their own organisation. The safety organisation will only execute aspects that contribute to safety ambitions or increasing the culture of safety. The tasks executed by the safety organisation should form an addition to safety management practices of individual parties, by coordinating or improving safety management aspects on a central level.

CONCLUSION

Discussion
Limitations
Implications

7. Discussion

This chapter discusses the results obtained in this research. First, the results are discussed (section 7.1), then the research impact (section 7.2) and finally the limitations of this research (section 7.3).

7.1 Discussion of Results

This section will discuss the results by focussing on the various aspects: preconditions, mandate, compositions and tasks. To end the discussion some general aspects will be discussed.

7.1.1 Preconditions

The safety organisations' preconditions are similar to preconditions that are present in the partnership literature (Chan et al., 2004). Similar to partnerships, the preconditions will form an important basis on which further collaboration will be built. Both the research results and literature show the importance of adequate resources, the need for an open culture, commitment of the parties and the importance of good relations. All are identified as building blocks for the relations and trust between parties in partnerships (Larson, 1997; Chan et al., 2004; Chan et al., 2003) and Hale (2001) indicates the importance of having these aspects in safety collaboration. Having trust and good relations will be of importance to collaboration success, failure in the relations or trust can quickly result in failure in the collaboration (Chan et al., 2003).

Drexler and Larson (2000) indicate that partnerships do not form a static relation, they change over time. Enough effort should be made to keep the relation between the different parties healthy, especially when though problems occur. Comparable results have been found for the safety organisation. Continuous efforts should be made to keep the relations healthy during the lifetime of the safety organisation. Larson (1997) state that during though problems, special attention should be put towards maintaining relations between partners. For the safety organisation this could occur during (major) safety incidents.

Milch and Laumann (2016) found that there are problems in private-private safety collaborations due to the differences in knowledge and or experience level. The gathered results in this research indicate that respondents expect that this will also be the case in public-private safety collaborations. The differences should be accepted and known beforehand, this could make it possible to put attention towards reducing the differences in knowledge.

Missing preconditions

One aspect responsible for partnering failure that did not come forward during the research was the misunderstanding of the partnering concept. As explained by Chan et al. (2003) this means that the parties need to have the knowledge and the understanding of what is required for the partnering process. This knowledge should be communicated to all participants to create a basis of understanding. This aspect was slightly touched upon in ID-102. This respondent indicated that all recent changes in the safety organisation should be communicated to all parties and training should be given to new employees. This is with the purpose of keeping all employees knowledgeable about the safety organisation, which relates to the prevention of the misunderstanding in the partnering concept.

Chan et al. (2004) describe 'productive conflict resolution' as an additional critical factor in construction partnering collaborations. The differences between the parties in e.g. expectations, goals and culture could cause conflicts. Conflicts often result in undesirable solutions, ''failing to reach a win-win situation'' (Chan et al., 2004, p. 191). Joint problem solving for finding solutions or alternatives for the issue is found in the most successful partnerships. Such aspects have not been found during this research, perhaps this aspect could be found during more (long-term) investigation.

7.1.2 Composition

The composition of the safety organisation consists of a safety meeting and a response panel. With respectively safety managers and workforce representatives participating. It is important that all parties are involved, both client(s) and contractors should be able to participate. Scholars Vassie and Fuller (2003) found that involvement of all contractors in managing safety helps with the level of safety reached. Involvement of all parties creates the opportunity to create a better safety record since projects with actively participating owners perform better and achieve lower safety numbers (Huang & Hinze, 2006; Gambatese, 2000).

Abudayyeh, Fredericks, Butt and Shaar (2006) state that the involvement of workers in safety policy making has positive effects, such as higher motivation to execute policies, higher personal responsibility and reporting more feedback. Empowering the workforce can have additional positive safety outcomes. ''Safety can become the workforce's own personal goal and responsibility'' (Abudayyeh et al, 2006, p173). This supports the involvement of the workforce in the safety organisation and the response panel could help with greater involvement and empowering of the workforce.
As indicated by ID-105, ID-107 and Hart (2002) people will only contribute when they see results from their actions. The success of this involvement of the workforce will be dependent on the results from their involvement. The safety panel should actively act on the presented ideas to ensure the continuous involvement of the workforce.

While the data found that the composition of the safety meeting should be safety managers, this will limit the different views present during these meetings. People with similar background or educations will have similar views, perhaps it would be useful to have people involved with different functions & backgrounds. If these people could fulfil the role of devil's advocate, they could introduce different views and opinions into the safety meeting. Every project could have different parties participating in the safety organisation, parties that are participating in the project for long periods of time could be valuable participants. This will results in different compositions among different projects, small contractors, large contractors, one cliental party or multiple.

7.1.3 Mandate

The results show that the safety organisation should have an advisory function. Which is comparable to the safety collaboration case investigated by Hale (2001). His study focussed on a similar safety collaboration and showed that actors were hesitant to transfer liability to such a shared organisation. Instead, they kept all legal obligations within the parties themselves. Their commitment to supporting this organisation was based on a shared agreement in which rules and support of the organisation were stated and this agreement was signed by all. These findings are comparable with the results obtained in this research. Having written documentation displaying the parties' support could help with maintaining commitment over time. Nenonen and Vasara (2013) found that one of the most common problems in safety collaborations is the weak commitment of the parties involved, showing the need for documenting and maintaining parties commitment.

The initial goal of the safety collaboration case (Hale, 2001) was to incorporate one set of safety procedures by creating a central safety organisation. However, this turned out to be overly complex. The organisation's responsibilities remained at a ''level of coordinating safety procedures of individual actors'' (Hale, 2001, p. 142), and the organisation had limited levels of power. This research found comparable results, indicating that coordination with limited legal power is best suited for the safety organisation. The safety organisation could be complementary to projects that recognise the benefit of not changing legal responsibilities and is possible to implement in most existing construction projects.

Differences between the safety organisation and the Schiphol case by Hale (2001) are seen in the different industry, different goal and different scope. The Schiphol case changed into a body overseeing the whole countries' airspace and their goal was focussed on setting uniform procedures and setting policies for all parties involved. The safety organisation of this research, on the other hand, focusses on a project level and on coordination, learning and discussions between project partners in construction environments.

7.1.4 Tasks

For most tasks, no comparison can be made with Hale (2001). The safety tasks executed in construction projects are different compared with operating an airport. Despite these differences, some similarities are found such as the importance to create a common goal and vision of what should be achieved. Such clearly described goals help in monitoring the tasks and identifying what should be improved. Comparable with any management system or program there is a need for reviewing and assessing progress. Both in safety management and partnering literature, it is expressed that audits and reviews help in continuously improving the process (Alarcón et al., 2016; Chan et al., 2004, Black, Akintoye & Fitzgerald, 2000). Setting a vision and goals could help with reviewing progress and improvement opportunities over the lifetime of the safety organisation.

One of the main tasks of the safety organisation is found to be to discuss safety aspects such as methods, problems, solutions and improvements. Similar to Hale (2001) this tasks should be one of the main tasks of the safety organisation. Chan et al. (2004) found that efficient coordination between parties is necessary to create stability in unstable partnership environments. Regular moments for coordination and information sharing will help in creating common ground, which is of benefit for maintaining the relations between parties (Nenonen & Vasara, 2013). Discussing safety helps with raising safety awareness (e.g. Hale et al., 2010). Therefore, safety discussions between parties are expected to help raise awareness and increase focus on safety.

Education and Communication

Safety education is an effective safety tool, it has been thoroughly investigated to help increase safety levels (e.g. Alarcón et al., 2016). Besides the positive effect on safety central, education could also have an impact on common problems encountered in safety collaborations. Milch and Laumann (2016) found that there are problems in safety collaborations due to the differences in knowledge and or experience level. While their research focusses on private collaborations, similar aspects are expected in public-private collaborations (identified in preconditions). Collaborative educational practices can help with creating similar levels of knowledge among all parties and their workforce.

Safety communication often goes hand in hand with safety education, many educational aspects are often communicated by mail, posers or briefings. For increasing the safety awareness among the workforce, there is a need for continuous attention to safety for which communication is a valuable tool (Abudayyeh et al, 2006). This supports the need for central safety communication, which is also found to be part of the tasks of the safety organisation.

Incident investigation

As found in the research, the shared handling of accidents could be a task for the safety organisation. This would at least be in the form of communicating the results to all parties involved, making sure that all can learn from the accident. Further collaboration could be that the parties help each other with investigating accidents and developing prevention activities. Dekker (2014) explains that accident investigation often focusses on the current circumstances and finding the cause of the accident (Safety-I approach).

The response panel could play a role in such incident's investigations, the workforce could help with finding the deviations, adaptations and changes which led to the incident. This would be part of adopting a Safety-II approach, to find ''why the aspects are different than the procedures'' (Hollnagel et al., 2015).

Ideas Workforce

As earlier discussed, the involvement of the workforce is needed. By gathering their ideas, knowledge, experience and irritations, safety could be improved. Capturing their knowledge is found in the results and in the literature (e.g. Hollnagel et al., 2015). This will require that the safety organisation will act on these initiatives by discussing and possibly implementing them. Acting on the experience of the workforce could help with aligning interventions with the workers' needs, which can have a positive influence on safety management (Hale et al., 2010; Dekker, 2014).

Inspections

The safety organisation's task for coordination of safety inspections is an aspect that originates from Safety-II thinking. Results show that the workforce expressed their concern about the many inspections that interfere with their work, distracting them from doing their work and generally taking time away from their work. This could lead to role overload and forms the origin of individual safety accidents (Mullen, 2004). The distraction that the many inspections form, pose a threat to the workers' ability to execute their tasks safely. Preventing too many distracting inspections could have a positive impact on workers safety performance.

Rewards

The research by Alarcón et al. (2016) shows that safety incentives and rewards could help with lowering the accidents rates. Positive rewarding could help with the increase in awareness and people looking out for their colleagues. This is identified as one of the possible tasks of the safety organisation. However, the downsides should also be noted. The implementation of safety incentives often go hand in hand with underreporting (of accidents) and creative accounting (Hinze et al., 2013). The occurrence of such behaviour should be known and acted upon during design and implementation of safety rewards.

Document knowledge

An aspect which received some attention in the results is the documentation of knowledge. Documentation of knowledge is not commonly executed in the construction industry (Fong & Yip, 2006). The case investigation shows that there are problems in gathering knowledge and experiences, which led to the safety organisations tasks of centrally documenting learnings. The documentation of knowledge would include the gathering of new safety practices, good or bad lessons learned and positive or negative experiences. Central documentation makes it possible for project partners to access this documentation and distributing it to their own organisations. This distribution of knowledge in the own organisations is difficult (results case study; Fong & Yip, 2006) and will require further research.

Missing Task: Risks?

The safety collaborations that Nenonen and Vasara (2013) investigated were mainly focussed on the coordination of safety education, safety communication and risks. Education and communication aspects have been found in this research, while risks have not been identified as a collective task. Their research focussed on Finish manufacturing companies with private-private collaborations between the contractors and sub-contractors. This different environment could explain that Nenonen and Vasara found that risks could be a collaborative task, and this research did not found risks as a collective task.

7.1.5 General Remarks

Contracts

An aspect that was discussed in multiple interviews (ID-101, ID-104, ID-105) is the contractual opportunity for increasing safety. Jazayeri and Dadi (2017) mentioned that one of the areas in which the client has an influence on safety management is contractual safety arrangement. Interviewees state that contracts describe safety in vague wording or prescribing non-helpful targets, making that these aspects are open for interpretation or non-helpful. Opportunities are identified for better written contractual safety paragraphs since this problem is prevalent in the whole Dutch construction industry.

Impact safety organisation

The method for a safety organisation as developed in this research will have some impact on the participating organisations. Some of the interviewees indicated opportunities that this safety collaboration will increase safety performance by creating more attention to helping and learning from each other and by improving and adapting safety aspects. Interviewees (ID-102, ID-103, ID-104, ID-106, iD-109) stated that they think the safety organisation will help improving the safety performance of the project and participating companies, but the preconditions will be critical in achieving this outcome. As stated, projects with actively participating owners are performing better and achieving lower safety numbers (Huang & Hinze, 2006; Gambatese, 2000), indicating that this private-public safety collaboration could have comparable results.

In some interviews, it was mentioned that the tasks of the organisation can change over time. That it could start with a focus on safety but that over time other aspects could become part of the topics discussed. This would be logical development because literature describes that 'Safety-II goes hand in hand with other aspects such as quality' (Hollnagel et al., 2015). Aspects such as money, performance, schedule, and other resources could also play a role in these discussions. It is important to realise that safety is not always the primary reason for changes, it could also be the secondary effect.

Practical Considerations Safety Organisation

The safety experts indicate that the implementation of the safety organisation could have a positive effect on the safety performance when some practical aspects are included. First, the response panel consisting of workforce expertise needs to have an important role in the safety organisation. The case study results show that the current safety management practices are focussed on showing safety with a lot of documentation and not necessarily on achieving safety during work execution. Similar problems could occur in the safety organisation and it should be prevented that the new safety organisation is too focussed on safety documentation. The response panel plays an important role in this. Similar to HRO companies (Binci & Cerruti, 2012; Pettersen & Schulman, 2019) it will be important to include the expertise of the workforce and their experiences in the execution of work. For achieving positive results (increasing safety performance) it is required to actively incorporate the ideas, recommendations and adjustments that the response panel proposes, which is supported by the ideas behind HRO methodology (Binci & Cerruti, 2012). Failure to include the workforce or failing to listen to their recommendations will lead to the problem that the safety organisation only focusses on documentation. As proposed earlier, having one representative of the response panel be part of the safety meetings could help in ensuring a practical view of the safety organisation.

Second, the shifting responsibilities and accountabilities of the different parties should be very clear. Implementing a safety organisation will create a shift in the normal safety practices and responsibilities. Aspects which are normally created, implemented and executed by a single organisation, could now be executed by a group of companies. The result is a shift in responsibilities and accountabilities and to ensure clarity, it is advised to create an overview of the different

responsibilities. A RASCI-matrix is a tool to create this overview. ''RASCI-matrices form a mechanism to represent the assignment of responsibilities of members of an organisation'' (Cabanillas, Resinas & Ruiz-Cortés, 2012, p.58). As identified in the research, an aspect found for the mandate is that it should be prevented that responsibility is put on people or parties that cannot bear it. By assigning clear responsibilities to people, using a RASCI-matrix, this could be prevented. The matrix can be created at the beginning of the safety organisation as part of the integral safety plan. The research shows that this plan should include a clear overview of obligations and responsibilities, which could be practically executed by using a RASCI-matrix.

Third, it will be important to appoint a coach or chairman that has the task to lead the meetings and keep the meetings on track. A major role will be present during the creation of the safety organisation, in which this coach could present different characteristics that can be included. Creating a new set of tasks, preconditions and mandate out of scratch will be difficult. The coach could introduce options (e.g. results obtained in this research) that could be incorporated in the safety organisation. The tasks of this role and the person executing this coaching role or chairman position should be documented in the integral safety plan and their responsibilities could be included in the RASCI-matrix. Further tips that apply during the implementation and creation of the safety organisation can be found in Appendix H 'Implementation Plan'.

Case Application safety organisation

Looking back at the investigated cases (phase 1), the application of the new safety organisation and the impact it could have is interesting to discuss. Since the safety organisation was not applied in reality the next sections is speculative.

Adapting safety procedures & instructions

The safety organisation would consist of the long-term project partners. In this case these are the representatives of the cliental party and the contractors who are involved for long periods of time. The application of a safety organisation could have a great influence on the irritations found among the workforce in the cases. Which were identified as e.g. irritations about educational activities, required documentation and other mismatches in procedures. The response panel would have the opportunity to voice these concerns, and subsequently, bring these to the attention of the safety managers. This could be the start of changes that will have a (positive) influence on the workforce, by either more suitable safety education or the possibility to remove or adapt bad safety procedures.

The involvement of the workforce could result in a set of adaptations or improvements to safety management practices. While these adaptations could lead to safer or better practices, it should be noted that there is some tension between procedures and adaptations. Too much freedom in adapting procedures could create exactly the opposite effect as intended, with the possibility of a decrease in safety performance (Dekker, 2003). The safety meeting (safety managers) should determine the appropriate level of adaptations possible to the current safety practices.

Incident

The incident that occurred in the 'Bomenkap' case is interesting to discuss. While it is not possible to state that this incident could have been prevented by implementing the safety organisation, it is possible to make some suggestions on how the outcome of the incident investigation could have been used. In the case, the incident was investigated by the main contractor, the client and the responsible sub-contractor. With the incorporation of the safety organisation this could be similar, however with the possibility that additional project partners could be involved in the investigation. What will happen with the safety organisation is that the outcome of the investigation will be discussed with all parties involved. This could result in better solutions, distribution of this new safety knowledge among all partners and increased awareness among all partners. If more partners have the knowledge and

experience of the incident, the more likely it is that these partners could prevent similar incidents from happening in the future. The safety organisation will thus probably result in a greater support base among the different parties involved.

Research methods used

In hindsight, the question could be asked if the phase two research benefited from executing two different data gathering methods (interviews and an expert panel). Beforehand, during the research design stage, the consideration was made to include multiple sources of data gathering to increase the internal validity. Now, it is debatable if these two methods were really necessary. From the point of internal validity, having multiple methods for gathering data is still useful. However, having a second source of data did not result in finding many new aspects and the usefulness of having two methods was less than expected beforehand. The conclusion that can be drawn is that the second research method helped in confirming the results found, but hardly led to finding new aspects.

7.2 Implication of the research

This part describes the contribution of the research, both for the scientific field (7.2.1) and for the practitioners (7.2.2), towards managing safety in a project environment.

7.2.1 Scientific Contribution

This research makes some contributions to the scientific field. First, this research adds to the safety literature with the development of a practical tool that partly incorporates the Safety-II school of thought. Current literature lacks the practical application of methodology, and the provided solution of this research to incorporate a response panel helps capturing Safety-II aspects in a concrete manner. The response panel is a contribution that provide many opportunities for new and additional research, which will be discussed in section 8.2.

Second, this research contributes to the collaboration literature by looking at safety collaborations between a public client and private contractors. The developed safety organisation adds to the current state of knowledge since it focuses on collective safety management by involving all project partner either public or private. Current safety collaboration literature focusses on circumstances where one (or multiple) parties set policies, rules and methods and other involved parties have to follow these guidelines. The developed safety organisation approaches safety management collectively, which provides a new approach to safety management and helps addressing the literature gap present in collective safety management.

7.2.2 Practical Contribution

The practical contribution of this research is the development of a method that could be applied in an existing project organisation to help increase safety performance. The safety organisation is expected to help increase safety levels over a shorter period compared to prevalent safety culture improvements. The positive aspects must be verified with additional research, but safety experts see the benefit of the safety organisation in increasing safety levels.

The developed method could be used in organisations that consist of different parties, either private-private, private-public collaborations or even single organisations. All these collaborations could benefit from the incorporation of a response panel consisting of workers. Depending on the project collaboration structure, the usage of the collaboration aspects could change since single party organisations will not benefit from these. The safety collaboration method as described in this research could help with increasing safety levels and behaviour.

7.3 Limitations

Every scientific research has its limitations, which should be highlighted to make transparent what impact these can have on the research. In previous sections biases and limitations of specific research methods have already been discussed. This section will discuss the limitations that apply to other parts of the research.

Exploratory Phase - Cases Studies

The case study executed in the exploratory investigation was only focussed on a single project within a single company. The selection of the cases based on their occurrence during the research limits the generalizability even more. Combined, these aspects increase the bias towards these specific (project) environments. Despite comparing these results with literature, the final outcomes are focussed on specific circumstances what limits the generalizability towards the entire construction industry. The limited timeframe of the research made it necessary to limit the research towards these cases. More research combining different data sources is required to improve the generalisability of the identified safety problems towards the entire Dutch construction industry.

Investigation Improvement Opportunity

The results found are based on a limited number of respondents. However, their broad experience and wide representation make the results representative for much of the industry. These characteristics of the respondents make it possible to generalize the results to the broader industry, but the characteristics of the safety organisation remain a rough outline. More data is needed to create broader support for the characteristics and the final impact such safety collaborations can have on the level of safety. This requires more research into the characteristics of such a safety organisation as well as research into the long term safety effects of the safety organisation. The long-term investigation should be executed to investigate the safety outcomes and the needs of the safety organisation during its lifetime.

8. Conclusion and Recommendations

This concluding chapter of this thesis contains the conclusion of the research by answering the main research question (section 8.1). Also, it provides recommendation for the scientific field and practitioners which will be discussed in the second section (8.2). The chapter ends with a small personal note on the research process (section 8.3).

8.1 Conclusion

This part of the chapter will focus on concluding the research. In previous sections of the research multiple sub-questions have been stated and answered. These sub-questions can be seen as the pieces that together form the answer to the main research question. The sub-questions are presented below.

SQ1: What is the current theoretical knowledge about safety management?
SQ2: How is safety management practically applied in construction environments?
SQ3: Which improvement opportunity should be further investigated for application in a construction environment?
SQ4: What are the preconditions needed for the public-private safety organisation?
SQ5: Who should be included in the public-private safety organisation?
SQ6: What is the mandate of the public-private safety organisation?
SQ7: Which tasks should be performed by the public-private safety organisation? Which tasks should be carried out by others?

> *How can safety management be improved in a public-private construction environment?*

The aim of this study was to help improve the safety performance of construction projects. The main question was divided into multiple parts, starting with the investigation of current safety management and what problems occur. Through investigation of theory and practice (SQ1 & SQ2), multiple safety management practices were investigated that resulted in identifying multiple improvement opportunities. Results indicate that despite the continuous attention towards the safety management systems that are used to manage safety in and around the worksite, these systems still do not ensure the safest working conditions. From the theoretical and practical investigations, a series of problems was identified such as differences in safety culture, setting bad safety targets, setting unsuitable prescribed procedures, safety only being managed by high office functions and safety differences between parties. Both practice and literature show that there are improvement opportunities for collaboration with regards to safety management. The literature adds that there are opportunities for incorporation of Safety-II, increasing the attention to what went right instead of what went wrong.

Based on safety collaboration literature, these improvement opportunities have been bundled into a collaborative safety organisation with the aim to collectively manage, discuss and coordinate safety between project partners (SQ3). Ideally, this would include some manner of feedback process that gathers the knowledge, experiences and needs of the workforce to improve safety management based on the Safety-II methodology. Based on existing literature, this safety organisation should be further investigated with special attention towards preconditions, composition, mandate and tasks.

Safety organisation

The investigation into the characteristics of the safety organisation resulted in a rough outline, focussed on the preconditions, composition, mandate and tasks of the organisation (respectively SQ 4, 5, 6, 7).

The ideal safety organisation would be a consultative body, independent of any of the project partners. It is identified that for the long-term success of the safety organisation multiple preconditions apply. These focus mainly on ensuring social interactions and relations, for example, ensuring and maintaining good relations, an open culture and the need for commitment of the parties.

The safety organisation should have an advisory role, supported by the commitment of the parties and their management. The safety organisation should not be based on a contract but based on the support of all parties involved. The support can be written down in an integral safety plan, stating the responsibilities, obligations and expectations. Collectively writing and signing the plan should state and ensure their commitment.

The composition would consist of safety knowledgeable representatives of the project partners (the safety meeting) and a response panel consisting of workforce representatives. These two groups should work together to give advice about adapting, improving and coordinating safety procedures between parties.

A range of safety tasks could be executed by the safety organisation but parties themselves have to collectively choose which ones will be executed on a central level. Some examples of tasks which can be executed by the safety organisation are creating a central safety discussion, creation of vision and goals, central safety communication, safety education, safety knowledge documentation and the implementation of ideas from the workforce.

Based on the answers to the sub-questions it can be concluded that safety management in a public-private construction environment can be improved by implementing a collective safety organisation with the above mentioned characteristics. Safety experts predict that public-private safety collaboration in the form of a collaborative safety organisation could help with handling and improving many safety problems encountered. This will require the project partners to be open to collaboration and interested to improve their safety management. This requires some investments but could result in a series of benefits. For example, the increase in project partners learning from each other, achieving more equal levels of safety and proactively improving safety.

8.2 Recommendations

Based on the research limitations, some recommendations are presented. These are divided into scientific recommendations (8.2.1) and practical recommendations (8.2.2).

8.2.1 Scientific recommendations

The first recommendation for future research is to execute longitudinal research into the integrated safety organisation. During implementation new aspects could be identified which are of importance. Over the lifetime of the organisation changes could occur, characteristics could become obsolete or new ones could be required. Interesting aspects to investigate are if, how and why characteristics change over time. Also, interesting is what the impact of the safety organisation will be on participating partners and sub-contractors. Overall, longitudinal research should investigate the relation between a safety organisation and safety levels, if meaningful relations between them can be found.

More research is needed into similar safety collaborations because more research in similar or comparable collaborations could help to build a wider set of data. This would make it possible to investigate for example, differences in characteristics or requirements, the impact of collaborative safety management and it makes it possible to design a wider applicable model for a collaborative safety organisation.

The safety organisation is partly based on the Safety-II school of thought. Research opportunities are seen in wider application of this methodology in the safety management systems of companies. For example, how current safety management elements could be adapted or changed to incorporate Safety-II aspects. This opportunity could improve safety management systems and help adapt the systems to the needs of the workforce.

8.2.2 Practical recommendations

The purpose of this part of the chapter is to state recommendations for the graduating company as well as for public or private organisations that have the ambition to increase their safety performance or the ambition to implement a safety organisation.

Safety organisation

For parties that have the ambition to set up a similar safety collaboration, this research can be of great value. The research' results provide a rough outline of a collaborative safety organisation and adaptations or additions can be made when desired. This safety collaboration method focusses on projects that wish to collaborate in managing safety and on project partners without contractual collaboration agreements. Considering the great importance of relations, trust and an open culture among collaborating parties, the recommendation is to give these aspects special attention while setting up a safety organisation.

Collaboration

Organisations do not necessarily have to implement a safety organisation as presented in this research to benefit from collaboration between parties. Collaboration or discussions can be also initiated between the client(s) and contractor(s) based on other aspects, such as quality, working conditions, efficiency etc. Collaboration in each of these aspects can help with the overall projects' performance. Additionally, shifting between topics should be encouraged. Safety does not have to be the starting point. It can also be the result or even a mediating outcome. Therefore, the recommendation to project companies is to start a collaboration between the different parties. The resulting discussions will lead to increased project performance. Even when safety is not the initial goal, it can benefit from discussions about other aspects.

Company Response Panel
This research showed that companies can benefit from having their own response panel. The reviewing of (safety) rules and procedures will be important to improve the company's (safety) management system. Therefore, the advice to organisations is to start gathering this information, analyse it and act upon the suggested improvement opportunities. In line with this, another recommendation for companies is to have more attention to Safety-II thinking. Current safety management is mainly focussed on faults, accidents and prevention. However, more attention towards what went well and good practices could improve an organisation's safety performance even further.

Improve Contracts
The last practical recommendation is about contracts. As mentioned before, many safety experts see problems in how safety is addressed in contracts. The aspects are often vague described and not helpful. Therefore, the recommendation is to put extra attention towards safety in contracts. Clearer and relevant elements could help clients with managing safety more effectively. Also, because contracts can be a point of disagreement and discussion, a better and clearer contractual basis can help uphold the safety standards by the different parties.

8.3 Reflection

''No research is ever quite complete. It is the glory of a good bit of work that it opens the way for something still better, and this repeatedly leads to its own eclipse''
Marvin Gordon

This quote explains my research process and how it feels very well. Doing research for months is something that felt unusual. Focussing on a single topic for a long period of time was a new process and it had its ups and downs. At the start, the time for the research felt like a luxury, but in a blink of the eye a lot of time flies by. The safety topic is very broad. There are many interacting elements and numbers of opinions and views on how safety should be achieved. This enormous topic makes it quite easy to lose yourself and to investigate every single aspect. This is one of the aspects that I would have done differently. I lost myself in the large amount of literature and that resulted in losing a clear picture of the research goal.

One aspect that I would have liked to turn out differently is the gathering of data. Unfortunately, the lockdown due to the corona virus influenced the gathering of data. Some of the interviews had to be conducted by means of using Skype. Personally, I would have liked to conduct all interviews face to face. I think this would have helped with interactions and it is in my opinion more enjoyable.

If more time would be available
Personally, I would have liked to study the effects of implementing such a safety organisation and its impact on the safety levels. It would be very interesting to see if the rough model I have designed would eventually influence safety. Especially, because this is of course the main goal of doing research into a safety topic. As the quote by M. Gordon state ''it opens the way for something better'', and I hope that this research would help start more investigations into this topic.

I can say that all the knowledge gathered during this research will be helpful for me. Safety is an ongoing topic and will become more important in the future. Having knowledge of this complex topic will be a benefit and I think safety will keep being an important aspect in the construction industry. The combination of these learning aspects with the experience of day to day interactions in a project environment was very useful. This was an experience that was a great opportunity for personal learning, and I will absolutely benefit from it during the start of my career.

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ACKNOWLEDGEMENT

The author wants to thank the following people for their contributions and support during the development of this thesis

Prof.dr.ir. P.H.A.J.M. van Gelder
TUDelft

Dr.ir. M.G.C. Bosch-Rekveldt
TUDelft

Dr. F.W. Guldenmund
TUDelft

Dr.ir. R. Favié
BAM Infra B.V.