The influence of leadership on the prevention of safety incidents: on risk reduction, leadership, safety principles and practices

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The influence of leadership on the prevention of safety incidents

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To all people exposed to safety hazards and their leaders

Preface

It was September 2013 when Ferdinand Mertens asked, “Victor, how are you progressing with the writing of your book…?” When I replied rather negatively, he said, “The reason there is no book yet is that you haven’t set a concrete goal! Why not work towards a PhD?” Bart van den Reek then challenged me: “Yeah, why not? Do it!” After pondering on this for a few days, and having received heartfelt support from Riet de Haan, I took the plunge and reported to Adriaan in ’t Groen, who admitted me as a candidate at the Dual PhD Centre. I am grateful to you all for your encouragement.

The subject of the present study is occupational safety and the involvement of leaders at every organisational level, from frontline supervisors to CEOs. As I believe that followers’ behaviours are shaped by the behaviour of their leaders, my objective was to discover how the former perceive the influence of the latter. It took me more than eight years to find what I was looking for. The material costs were affordable and the immaterial gains were priceless. In addition to my academic findings, I found that obtaining a PhD degree requires teamwork; it is impossible to complete one without the help of others. In my case, many were anonymous, some were unwitting, and several were indispensable. I would like to express my appreciation to one and all.

Yolanda de Graaf was my co-pilot and academic mentor from the project’s conception. She advised me on structure, design, style, language, and many other aspects. She joined me in conducting (at least) 75 interviews and numerous presentations across the country. She read every letter I wrote, suggesting how I might re-phrase things and approving my drafts. Without her creative and committed support, this dissertation would have never existed. Yolanda, thank you so much!

I am grateful to my contacts in 33 organisations who persuaded 4,561 of their colleagues to complete my prospective survey questionnaires. No respondents, no research! This also applies to the Tripodian incident investigators and the professional risk analysis experts who anonymously shared their knowledge and experience with me to find the retrospective data I needed. I would like to thank Geesje Saijs, Linda Drupsteen, and Mark Van Houdenhoven, who convinced me that my crazy plan was a good idea and helped me kickstart it. Viola van Guldener, Frank Guldenmund, Harold Janssen, Ed Janssen, Jakko van Kampen, Geert Lentz, Roger van Meer, Ronald Pijtak, Francien Rense, Jan Treffers, Koos Visser, Marith de Vos, and Jakob van der Wal kept me on track during my journey, and Herman de Bruine made an important contribution by deep digging discussions and exposing me to his critical students.

I am indebted to Dion Woestenburg, who played a key role in generating the statistics I used to arrive at my conclusions; Steven de Bie, who advised me on how to structure the retrospective section and distil 240 pages into just seven; eagle-eyed Christiaan Verwer, who scrutinized most of the text and corrected my many language errors; Bart Kelderman, who did the beautiful oil painting on the cover of this book; and Erwin Muller, Jop Groeneweg, and the staff of the Dual PhD Centre for their inspirational guidance and support. A special thank you is reserved for my personal coach Mark Dechesne, who spent many hours trying to help me understand what writing a dissertation actually means and guiding me through the academic maze to obtain my PhD.

Also, I am grateful to Jeroen, Lars, Bianca, Janine, Lou, Guillaume and Lot for giving me time to work on this thesis by allowing me limited presence on so many family occasions.

Last but not least, I am beholden to Riet for her tireless listening to my 'daily progress reports'. She acted as a sounding board from the initial design of the survey questionnaire until the drawing up of the final conclusions and recommendations. She reflected on my many dilemmas and ever-changing conceptual developments. Her unlimited support during the entire development of this thesis can't be appreciated enough.

To all of my family I apologise for limited attention I have given them during this project – I promise I will never do it again!

Risk is a reflection of what we feel.

PAUL SLOVIC

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Glossary

Ability	Opportunity, knowledge and skills to intervene to reduce risk.
Action	Remedial action required to reduce identified risk.
Courage	Courage to put safety first if needed to intervene to reduce risk.
Dominance-oriented	Self-centred, sometimes even narcissistic behaviour, person who is only interested in his personal priorities.
Event History	Indication by survey respondents about what has gone wrong in the field of safety within an organisation in the past year.
HSEQ	Health, Safety, Environment, Quality
Intervention	Intervening act to manage risk (may imply cease of primary process)
KPI	Key Performance Indicator
Leadership orientation	Characteristic of a leader's behaviour.
Motivation	Internal will to intervene to reduce risk.
P&ID	Piping and Instrumentation Diagram
Primary process	The process by which an organisation produces its added value (also 'Risk Generator').
Process-oriented	Behaviour focused on improvement of processes with fundamental respect for quality and safety related aspects of the primary process.
Production-oriented	Behaviour primarily focused at meeting production targets.
Recognition	Awareness and acknowledgement of risks.
Relation-oriented	Behaviour that values interpersonal relationships and cares for the social climate at the work place.
Remedial Action	See Action
Risk Potential	Indication by survey respondents about the potential risk of accidents
Risk Reduction Capacity	The aggregated scores of the five phases of the Risk Reduction Cycle.
Risk Reduction Cycle	A five-phase model to measure the ability of an organisation to reduce safety risks.
Safety Leadership	The aspects of leadership focused on risk reduction
Safety Leadership Model	A model displaying the hypothesized relationships between leaders' behaviours, risk management and safety.
Sense of Safety	Indication by survey respondents how safe they feel in their organisation.

All descriptions are not equal; some seem accurate and informative while others are fanciful or absurd.

KENNETH GERGEN, 2009

Reading guide

The objective of this research is to discover the relationship between leadership characteristics and the occurrence of safety incidents. Chapter 1 (Introduction) is the introduction to this research. The core of this dissertation are the relationships between 'safety', 'risk management' and 'leadership'. In Chapter 2 (Theory, Concepts and Context) we discuss the relevant theory, concepts and operational context. In Chapter 3 (Empirical Research), we describe the scope of the research, our basic assumptions, the research questions and the methodology. The research takes two approaches, following a prospective path and a retrospective path. The prospective study is described in Chapter 4 (Safety Leadership Model). Here the core notions (safety, risk management and leadership) are synthesised into a 'Safety Leadership Model', which specifies the interrelationship between leadership characteristics, risk management and the prevention of safety incidents. The core notions are also complemented in this chapter by specific characteristics (i.e., the behavioural orientations of leaders, risk reduction phases and safety characteristics), and then these characteristics are included in the Safety Leadership Model. Chapter 5 (Prospective Study (pilot survey)) describes the design, procedure, materials and results of a prospective pilot survey. Chapter 6 (Extended Prospective Research) covers the design, procedure and materials, results and the statistical analysis of the follow-up to the pilot survey, the extended prospective survey. Chapter 7 (Reconsideration of Primary Prospective Analysis) presents the reconsidered results of the prospective survey and the concluding taxonomy of survey indicators, as well as the Safety Leadership Model, as modified on the basis of the reconsidered analysis. The results of the prospective survey are presented in Chapter 8 (Prospective Survey Results). Chapter 9 (Retrospective Views) contains information about the retrospective approach. The views of incident investigators, risk analysis experts and the Dutch Safety Board are reported here. Finally, the findings of this research study are interpreted, the research queries resolved, and the meaning of these findings discussed in Chapter 10 (Valorisation). Our final conclusions and recommendations are provided in Chapter 11 (Conclusions and Recommendations). Chapter 12 (Summary) is a summary of this research (in the English and Dutch language). The Author index, References and Appendices are located in Chapters 13, 14 and 15.

Important aspects of risk and safety are about general social and behavioural dynamics, rather than specifically about risk and safety.

ARIE RIP

1 Introduction

This research concerns operational disturbances in organisations where safety risks, if insufficiently controlled, may lead to safety incidents resulting in personal injury, asset damage, pollution of the environment, interruption of primary processes, reputational damage and ultimately damage to an organisation's fundamental values. We argue that reducing safety risks results in increasing safety.

Leaders are generally regarded as important, probably even key elements with respect to the operational performance of organisations, which includes risk management. They are therefore also considered an important factor in the management of safety in their organisation. According to Flin: "A potential fruitful research avenue is to study the influence of senior managers' leadership styles in relation to safety."[1]

We believe that leadership at any organisational level plays a role in risk management, and so we take an extended look at leadership, and consider all members of organisations with leading roles at strategic, tactical and operational levels. This means that we include CEOs, managers, department heads, shift supervisors, and so on.

This research aims to provide clarity about the relationship between the way leaders play their leading roles in the organisational unit for which they are responsible, and the effectiveness of managing safety risks related to primary production processes. This clarity may serve as an aid to improving the effectiveness of leaders where risk management is concerned, and thereby contribute to preventing future safety incidents in organisations.

From a historical view, numerous experts have contributed to optimising the reduction of operational disturbances in many ways, using different models and approaches, but primary processes and operational equipment are seldom fully failsafe, and so safety incidents still occur. To compensate for shortcomings in the design of processes and equipment, organisations make a great deal of effort to change the behaviours of the operational people using those suboptimal processes and equipment. The application of the referred models and approaches has apparently not so far led to the intended result, however: optimal safety.

We argue that one probable reason for limited success is that safety-related data gen-

1 Flin (2003), p. 264.

erated by external sources (e.g., inspection/audit reports) does not have a sufficient effect on people, and even makes them feel sceptical about the findings of 'strangers', and hampers their motivation to change. In this respect, we hold that doing the same thing over and over again will not lead to better results.[2] Our contribution to the pursuit to safer primary processes, using scientific methods and references, is therefore to support an approach in which we identify the individual perceptions of members of our research population, based on a) trust in people and b) our belief that data from external sources (i.e., inspectors, auditors, consultants, etc.) is not always an effective moderator for changing people's behaviours.

We refer to the Thomas' theorem: "If men [sic] define situations as real, they are real in their consequences."[3] This is also the view of Soliman and Wilson, who argue that: "Lay theories can be thought of as a general lens through which people perceive and interpret the qualities of individuals, groups and the world around them. They are fundamental knowledge structures that – although often 'implicit' and not explicitly articulated – can have powerful effects on behaviour."[4] Flin phrased it as follows: "The safety culture of an organisation is determined by the perceptions of management commitment to safety, as judged by the workforce."[5] In our safety-focused research, we note the view of Reniers, who argues that the people's *safety-related perception* is one of the three core domains of safety.[6]

On this basis, we put the hearts and minds of our research subjects (leaders and followers, members of organisations) at the centre of our study. We have high respect for the discernment of individuals, who are strongly connected to operational processes and who, as potential victims, know how safety risks and the behaviours of their particular leaders *feel*.

We focus on the individual perceptions of the researched group members. Where applicable we will analyse, interpret and comment on the data as delivered by this group. This complementary approach is used to hopefully deliver the optimal culture-independent research outcome.

Safety incidents have various causes and manifest in different ways.[7, 8] Depending on the specific circumstances and the amount of energy involved, the development of an incident and its specific consequences differ in severity.[9] The author's curiosity about the actual contribution of leaders and followers in the causation of safety incidents, as well as his personal aspiration to contribute to an increased level of safety in the sectors

2 A reference to a quote attributed to Albert Einstein: "Insanity is doing the same thing over and over again and expecting different results."

3 Thomas (1928), p.572.

4 Soliman and Wilson (2017), p. 105.

5 Flin (2003), p. 265.

6 Reniers (2020).

7 Groeneweg (1992).

8 Gawande, Thomas, Zinner and Brennan (1999).

9 Dekker (2011).

in this research, were the motivation for conducting this study. We suggest that research conclusions about human relations and other contextual working circumstances, based on individual perceptions of the people involved, may offer new insights followed by changes in thinking, which is required to amend deeply ingrained routines in both leadership and followers, ultimately resulting in fewer safety incidents. This research aims to contribute to this objective.

In the next chapter we will discuss the theoretical framework underpinning this research, and risk management concepts developed by scholars and safety professionals. We also elucidate the contextual factors faced by leaders in their attempts to optimise the safety of the processes for which they are responsible.

> Science is not a purely objective, value-free activity of discovery: science is a creative process in which social and individual values interfere with observation, analysis and interpretation.
>
> MARJOLEIN VAN ASSELT

2 Theory, concepts and context

Safety in organisational settings has developed since the late 19th century, from individual initiatives by industrial, transport and health care frontrunners to academically-supported concepts by scholars and safety professionals, who have studied how and why processes sometimes do not result in the desired results. Due to the fact that safety incidents still occur, there is an ongoing drive to develop better theories and more effective concepts. Every publication of a new theory, philosophy, or concept raises a debate between scholars and practitioners, and often a reaction from society. Some approaches are similar; others are opposite in nature, or based on different theories or philosophies. Some of these developments have inspired risk management professionals, have been immediately embraced by many people, and became internationally influential. These theories and concepts serve as references for this research, in order to clarify how contemporary risk management methods influence leaders in organisations in their efforts to prevent safety incidents.

In this chapter we will elaborate on the theories and concepts related to safety, risk management and leadership. We will then discuss the contextual factors that leaders are facing (and part of) during their day-to-day work.

2.1 Safety

Nobody wants to be involved in, or held accountable for safety incident scenarios, but, like it or lump it, these scenarios are part of the real world; things may run differently than expected. Primary processes may be disturbed and escalate into safety incidents without warning. Organisations attempt to prevent operational disturbances in different ways, but simultaneously, in order to survive economically in a competing environment, or simply to make life easier, people take initiatives that are counterproductive to this preventive process. Most of the time, they do this with the best intentions. This not only applies at the operational level; under the influence of, for example, personal, economic, political, or peer pressure, people deviate from approved policy strategies and agreed scopes of work.

This is the case in any phase of an operational process; be it design, engineering, procuring, construction, selection and hiring of personnel, education and training, operating the primary process, inspecting, auditing and testing, maintenance, or decommissioning. During all these different activities, individuals at different organisational levels take initiatives and people may have reasons to deviate from agreed safe practices; on operational, supervisory, managerial and boardroom levels as well.[1]

Apparently, safety risks are not always waiting in front of people's eyes to be clearly observed or otherwise identified. It is often difficult after a safety incident, even for professional investigators, to identify the trigger that initiated the disaster, and the underlying factors which contributed to the occurrence of the incident. From the positive point of view that people do not cause operational disturbances deliberately,[2] it is reasonable to say that their actions, including deviations from instructions, procedures, standards, etc., are performed in good faith, often with the intention to increase the efficiency and effectiveness of the primary process. As a matter of fact, this is the way many process improvements have been invented. Hale and Borys also claim that strict compliance to a static set of rules is probably not the best solution to reduce safety risks.[3] To support this, a statement by Reason is considered relevant: "If people would always have followed the rules, we would still live in the caves…"[4]

An incident-free operation in sectors where serious safety risks exist is a myth.[5] Therefore it is no surprise that in the safety-critical sectors subject to this research, there are no organisations with an incident-free track record and, on the contrary, despite intensive risk management programmes, the list of organisations that have proven *not* to be able to prevent safety incidents shows many names.[6] In these sectors, safety risks, obvious and known, hidden and unknown and uncertainties are part of reality; therefore, an ongoing and continuous effort to identify and reduce safety risks is as fundamental as anything else for these organisations to stay in good health.

2.1.1 *Defining safety*

In the health care sector, patient safety is defined as: "The (near) absence of (the risk of) the patient inflicted injury (physical/mental)."[7] In the rail sector the term 'safety' has not been formally defined,[8] but the companies which operate railway systems in the European Union are obliged to comply with EU Directive 2016/798, which contains extensive safety requirements (although no definition of 'safety' is given). In this directive the clos-

1 Hollnagel, Woods and Leveson (2006).

2 In case process disturbances are caused by deliberate subversive actions, the term 'sabotage' applies instead of an 'unintended incident.' This has no relationship with safety, but with the security discipline. Security cases are outside the scope of this research.

3 Bieder and Bourrier (2013).

4 Commentary by Reason in the documentary "Impossible Accident" about the sinking of the Herald of Free Enterprise in 1987.

5 Yoe (2012).

6 Swuste, Van Gulijk and Groeneweg (2017).

7 De Bruijne, Zegers, Hoonhout and Wagner (2007), p. 16.

8 Directive 2016/798 of the EU (2016).

est indication of what is meant by the term safety is that safety performance is measured in terms of the number of injured people and material damage.[9]

From an entirely different angle, Yoe refers to legislative and administrative frameworks, in which safety is defined as: "a reasonable certainty of no harm."[10] The notion of 'reasonable certainty' suggests that uncertainty plays a role, which Yoe connects with the possible existence of residual risk after all measures aimed at controlling safety risks have been undertaken; he argues that because of this uncertainty, safety in any absolute sense is a psychological fiction. Van Asselt suggests that 'uncertainty' is an inevitable element of operational activities, and she therefore advocates raising consciousness regarding the impossibility of escaping uncertainty and risk.[11]

Aven claims that many safety professionals and researchers use definitions like "safety is the absence of accidents"[12] and similar versions in which safety is associated with low/acceptable risk. Other researchers argue that it is counterproductive to define safety as the antonym of risk, due to the different views on the definition of risk. Nevertheless, Aven recommends using risk-related definitions of safety (and safe), and he suggests that "…by using the risk interpretation we acknowledge that being safe is a subjective judgment dependent on institutional processes to determine what is acceptable risk and what is not." Aven thus rejects definitions in which safety is related to the concept of an "absence of accidents."[13]

Aven finds support from Dekker, who claims that defining safety in terms of the absence of something, because systems are already safe, is a faulty assumption. In his view, all systems contain incompatible opposing goals and are always short of people or technical safety characteristics, both of which are considered too expensive. He suggests that people at all levels in organisations are the only ones who can resolve these shortcomings and thereby create safety through practice. Dekker claims: "Safety is not about the absence of something. It is about the presence of something."[14] The medical discipline gives a clear example of this approach: the term 'health' is usually described by its implicit properties (e.g., vitality, fitness, or well-being, etc.). No unambiguous solution has yet been developed for safety.

Weick's definition is in line with the previous options, as it proposes to define safety as "a dynamic non-event".[15] In his managerial concept of High Reliable Organizing (HRO), reliability is a precursor of safe operations. Weick claims that reliability is a moving target, and therefore transient, and that reliability is a dynamic non-event, and therefore continually re-accomplished. He explains that operational activities are constantly subject to interference, and therefore 'balancing' is required to reliably perform activities and pre-

9 Heimplaetzer and Busch (2006).

10 Yoe (2012), p. 4.

11 Van Asselt (2000).

12 Aven (2014), p. 16.

13 Ibid., 16–17.

14 Dekker, Hollnagel, Woods and Cook (2008), p. 2.

15 Weick (2011), pp. 21–27.

vent an event. Weick argues that "when balance is interrupted, cognition and feeling arise and turn a non-event into an event."[16] According to Weick, continual actions to keep the balance form the dynamics required to ensure that we achieve our operational goals in a safe way. In order to elucidate the dynamic nature of safety, he uses the example of rope walkers, who continually react to the forces that affect their balance.

This brings us to Hollnagel, who also recognises that the status of safety science is contested. In a discussion in which he reasons that safety science is 'the study of safety', he concludes that

> … unlike the celestial objects, unlike matter, even unlike faculties, organisations, goods and services, *safety* does not represent an agreement on what it is that should be studied, nor can it be said to exist in any concrete or material sense, or to be real. Because of this we cannot resolve disputes about what safety is by referring to something that exists independently of our thinking, as if it was an object (as the term is used in semiotics). Yet we need to be able to refer to what *safety* is in a way that is open to intersubjective verifiability…[17]

Hollnagel[18] has noted that safety is often defined as a condition where no incidents happen, or a condition where the number of incidents is acceptably small. He refers to various definitions in use, such as:

– The state in which harm to persons, or property damage, is reduced to and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management. (International Civil Aviation Organisation);
– Freedom from accidental injury. (U.S. Agency for Health-care Research and Quality);
– A major incident is an incident or natural event that poses a serious and immediate risk to safety and includes a derailment of rolling stock, a collision, a fire or explosion. (Transport Safety Victoria).

Hollnagel states that these definitions are merely defining a 'lack of safety', rather than safety. A lack of safety is measurable, as incidents can be counted but it is impossible to measure safety when defined as a state of non-incidents. Here we face the core problem with defining safety solely by an absence of incidents. Hollnagel developed a solution for this problem: safety should be defined by 'what IS there', instead of 'what is NOT there'. Therefore, he proposes focusing on 'what goes right' rather than on 'what goes wrong'. This approach has been termed Safety II, and the related definition reads:

> Safety is the ability to succeed under expected and unexpected conditions alike, so that the number of intended and acceptable outcomes (in other words, everyday ac-

16 Ibid., p. 23.
17 Hollnagel (2014), p. 21.
18 Ibid.

tivities) is as high as possible.[19]

Apparently, the safety-world feels (rightfully) uncomfortable with the old view that 'safety is no accidents'. Nowadays there is growing support for the new view – the Safety II view – in which, according to the founding fathers of Safety II (Hollnagel, Woods and Leveson), "… the notion of resilience has gradually emerged as the logical way to overcome the limitations of existing approaches to risk assessment and system safety."[20]

Hollnagel himself realises that "the real difficulty in this approach is to change the mindset of safety scientists, from a focus on that which goes wrong to a focus on that which goes right",[21] and we agree with him; safety professionals and researchers are puzzled, and the discussion about what is referred to as Safety I and Safety II in the profession is very much alive. Despite an active debate among numerous safety experts, there has been no unambiguous agreement among the safety community about how these two concepts relate to each other, until now.

2.1.2 *Safety theories*

2.1.2.1 Domino theory and accident pyramid

At the turn of the 20th century, the industry in general, suffering from bad safety records, became aware that their employees deserved a higher level of protection. Unions had taken occupational safety as an important topic. As a result, companies and trade unions initially focused on raising awareness of the (mostly mechanical and electrical) safety risks by warning general employees of their dangerous surroundings; awareness was considered the key preventive measure. In 1931 Herbert W. Heinrich, an employee of the Travelers Insurance Company (Hartford, CT) published his book 'Industrial Accident Prevention: a scientific approach.'[22] Of significant influence was his description of a 'domino theory', advocating that an accident follows a deterministic (if>then) causal path. Also, he described an 'accident triangle' or 'pyramid', showing a ratio between different severities of incidents and accidents. Many criticise the scientific validity of the domino and triangle concepts and these are still subject to discussion. But the completeness of his work is striking and its impact on industrial safety is beyond any doubt, as, scientifically proven or not, these concepts have survived as 'a way to look at the management of safety.'

Heinrich introduced four fundamental principles of accident prevention: 1. executive interest and support, 2. investigation and analysis of accidents, 3. selection and application of remedial action and 4. executive enforcement of corrective practices. These principles are of significant interest regarding the role of leaders. Apparently, Heinrich's

19 Ibid., p. 23.
20 Hollnagel, Woods and Leveson (2006), p. xi.
21 Hollnagel (2014), p. 23.
22 Heinrich (1941).

four principles touch on the central topic of this dissertation: the role of leaders in the prevention of safety incidents.

2.1.2.2 Normal Accident Theory

Since 1937, many organisations have supported the Bell System Safety Creed: "No job is so important and no service is so urgent – that we cannot take the time to perform our work safely."[23] But in 1979, Charles Perrow had the courage to declare that "Most high-risk systems have some special characteristics [...] that make accidents in them inevitable, even 'normal'."[24] This statement forms the centre of Perrow's Normal Accident Theory (NAT). He explains that accidents have to do with the complexity of systems and the way system components are tied together. The term 'normal accident' means that, given these system characteristics, unexpected interactions of different failures are inevitable. Perrow claims that by understanding this causal theory, "... we are in a better position to argue that certain technologies should be abandoned and others, which we cannot abandon because we have built too much of our society around them, should be modified."[25] Perrow's theory initiated an ongoing debate between risk management professionals and organisational leaders. Many reputable organisations still ignore NAT and support the 1937 Bell creed, proclaiming a 'Zero Accident' policy. However, NAT does not provide an indication of the frequency or probability of occurrence, but only indicates the plausibility of accidents occurring.

Perrow's theory relates a great deal to (the design of) technological systems, but this is put into the perspective of the number and quality of people present in operational areas. He emphasises the requirement that designers of technological systems ought to consider the intellectual and physical restrictions of operating people; e.g., people may be afraid to report small deviations of 'normal system behaviour', which appear infrequently and which never really disturb the production process ('weak signals'), but which potentially may lead to a safety incident. Already in 1979, Perrow included organisational influences in analyses of the integrity of the system as a whole (hardware and human-ware). NAT explicitly includes the option to refrain from an intention of building an innovative system if the system is too complex and the elements too tightly coupled for a person (or team) to understand the potential for failure or the recovery of failure. In NAT risk awareness in the design phase, leadership and courage to intervene on work floor level are considered important to prevent safety incidents.

23 First stated in 1937 in a speech by W.T. Wooters, Plant Manager of the Bell of Pennsylvania Company.
24 Perrow (1999), p. 4.
25 Ibid., p. 4.

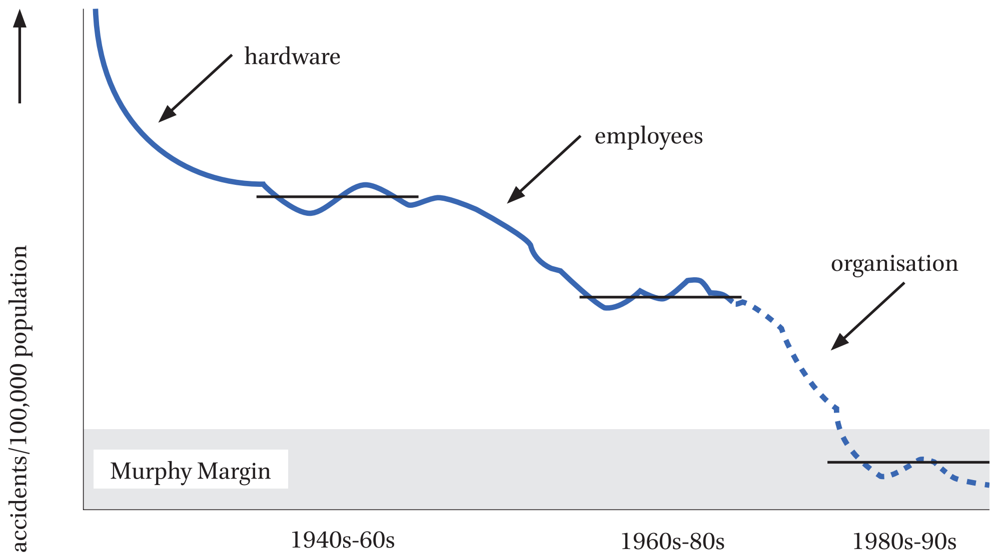


FIGURE 1 Trends in risk management (Groeneweg, 1992)

2.1.2.3 Murphy margin

In 1992, Groeneweg published *Controlling the Controllable*.[26] In this book, the author presents the theory that operational workers commit suboptimal acts (e.g., slips, lapses, mistakes, violations) due to the context and conditions in which they operate. This theory suggests that operational disturbances, potentially resulting in safety incidents, are the consequences of a suboptimal organisational process.[27] This publication initiated a trend which is characterised by a shift in attention from individual employees as the primary cause of accidents to organisational factors as precursors and underlying causes. Groeneweg also presented a so-called 'Murphy Margin', representing an area where effective risk management has achieved a level where very few accidents occur and where statistical analysis does not add to better understanding of why accidents happen. Groeneweg[28] explains our mental incapability to control all unexpected and undesired operational disturbances, as follows:

> There seems to be a zone of creeping entropy where factors beyond the control of both management and the people on the floor influence the number of accidents. This is a base level of the number of accidents and it seems impossible to reduce it further. This is a statistical phenomenon, since chance of getting an accident will

26 Groeneweg (1992).
27 Swuste, van Gulijk and Zwaard (2016).
28 Groeneweg (1992), p. 6.

never be zero in the long term and given a large enough sample size, there will always be accidents. Companies with a fluctuating number of accidents are not necessarily already in this zone, they could also be stabilising at a higher level. If and only if a company can prove that they have managed to control all technical, personal and systemic parts of the accident causation process, they can regard themselves being in that zone of creeping entropy, the Murphy Margin.

2.1.2.4 Disaster Incubation Theory

In 1997, Turner and Pigeon published their 'Disaster Incubation Theory.' This is a theory about the functioning and properties of high tech-high hazard organisations. Extensive observations and fieldwork in the British industry, transport and health care sectors serve as the basis for this theory and form an ethnographic approach.[29] The theory is that, before a disaster takes place (here: notionally normal starting point), various small process disruptions caused by unacknowledged underlying factors take place (Stage 1). People consider these disruptions as surprises and do not realise that these relative weak signals are in fact indicators that the production system is vulnerable to bigger trouble. When these signals are not valued as predecessors of something serious and there are no timely interventions, this period of weak signals is in fact the 'Incubation Period' (Stage 2) before a disaster takes place. When these disruptions lead to a 'Precipitating Event' (Stage 3) the 'Onset of a Disaster' (Stage 4) is inevitable. The model is completed by explaining the 'Rescue and Salvage' (Stage 5) and the 'Cultural Readjustment' (Stage 6), by which the organisation's culture is modified to prevent future process upsets. This theory is depicted in Figure 2 below.

According to Turner and Pigeon, disasters are a by-product of normal operating management and technical systems. The vast majority of underlying factors are of a managerial, administrative, or social nature; technical causes are the minority. The collective failure of the organisation and misconception about safety risks create incubation of safety incidents.

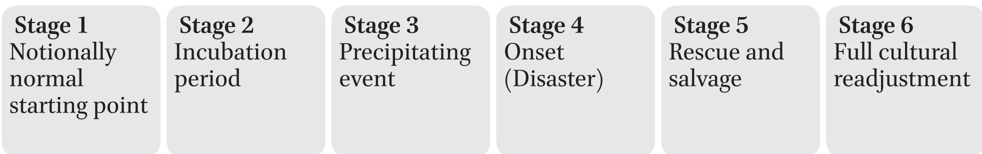


FIGURE 2 Disaster Incubation Theory

People under operational conditions are exposed to different dynamics, requiring various skills, of which being careful not to create a safety event is only one. Hollnagel explains the combination of these different forces as the 'Efficiency-Thoroughness

29 Swuste, Van Gulijk and Groeneweg (2017).

Trade-Off'-principle (ETTO), addressing the continual conflict between producing in the most efficient way and optimally managing safety risks at the same time.[30] Once it has become clear that trade-off decisions were not taken in favour of safety, this is often attributed to a lack of safety awareness among the people involved, however, when their knowledge and awareness of safety risks is tested (e.g., by asking their opinion about the hazards to which they are exposed), such a conversation often shows that people in operations have a surprising depth of understanding of safety-related aspects. People involved in the primary process often know more about operational safety risks due to their operating experiences, and are more creative in finding solutions to tackle incompatible goals than people who are not exposed to the day-to-day operational reality at the work floor level.[31, 32, 33]

Nevertheless, there is one exception to be made with respect to identifying safety risks; 'black swans', the hidden or even unknown-unknown risks (ref. 2.2.3.1.1) that cannot be identified by any individual working at a strategic, intermediate, or operational level. History has demonstrated that safety incidents have been caused by this type of latent hazard.[34, 35, 36, 37, 38, 39, 40]

2.1.2.5 High Reliable Organizing

Being professors in organisational psychology (Karl Weick) and medicine and business (Kathleen Sutcliffe) Weick and Sutcliffe are considered the founders of High Reliable Organizing (HRO). This concept, first published in 2001 focuses on 'managing the unexpected.'[41] This development may be considered a follow-up of Perrow's NAT, in the sense that its theoretical foundation is the acceptance of inevitability of accidents, as each process design contains weaknesses. But where Perrow has a strong focus on the design phase of systems, HRO emphasises more the organisational aspects and how to deal with unexpected developments in the operational stage. HRO is based on five principles: 1. Preoccupation with failures, 2. Reluctance to simplify, 3. Sensitivity to operations, 4. Commitment to resilience, 5. Deference to experience.[42] These principles seem to encompass the full risk management process, from recognition of risks to remedial actions

30 Lundberg, Rollenhagen and Hollnagel (2009).
31 Groeneweg (1992).
32 Dekker (2011).
33 Reason (1997).
34 Taleb (2010).
35 Onderzoeksraad voor Veiligheid (2019).
36 Onderzoeksraad voor Veiligheid (2015).
37 Onderzoeksraad voor Veiligheid (2013c).
38 Onderzoeksraad voor Veiligheid (2012).
39 Onderzoeksraad voor Veiligheid (2008a).
40 Onderzoeksraad voor Veiligheid (2007).
41 Weick and Sutcliffe (2007).
42 Ibid.

to reduce these.

Organisations which are considered 'High Reliability Organisations' distinguish themselves by the fact that their members are permanently alert to identification of (weak) signals of deviation from intended processes; 'collective awareness.'[43]

Westrum argues that when people bring new variables under their control and enlarge their ability to act on them, they also enlarge the range of issues they can notice in a mindful manner. And conversely, if people are blocked from acting on hazards, their observations will, most likely be considered as 'useless'. Consequently, these observations are ignored or denied and errors may cumulate unnoticed.[44] This contemporary approach to risk management has opened new pathways in an entirely different direction.

But not all organisations are prepared to embrace conceptions like 'mindfulness' yet. Therefore, HRO still requires translation by experts to enhance understanding by an operational population. However, the concept has the potential to guide organisations beyond the obstructive level of 'risk management by compliance.'

2.1.2.6 Resilience engineering

As another development, we include resilience engineering. In its development, Hollnagel, Woods and Leveson especially played key roles. The first formal sign of the birth of this concept was the Resilience Symposium in Söderköping (Sweden) in 2004. Dekker explains resilience as "the ability to accommodate change, conflict, disturbance, without breaking down, without catastrophic failure."[45] So, resilience does not focus on reducing incidents or human misbehaviours; it is about stimulating the abilities of people to cope with the challenges of the ever-changing processes they are expected to control. This concept sheds an entirely different light over safety science. In resilience engineering, systems are not protected against 'unreliable' people, who may err unexpectedly on critical moments and 'thus' need more individual discipline.

On the contrary, resilience theory assumes that systems and processes are seldom inherently safe and that only human beings, by their adaptive capacities of observation, interpretation and understanding, are the ones who can take right remedial actions before seemingly minor deviations of planned processes escalate into safety incidents.[46] In resilience engineering, safety is not a system property. Operational disturbances are identical to unexpected operational successes; both are considered surprises. Whether these deviations to the 'normal' are of a positive or a negative nature is considered 'performance variability.' As Hollnagel, Woods and Leveson write: "While we like to think of successes as the result of skills and competence rather than of luck, this view is just as partial as the view of failures as due to incompetence or error."[47] This view on risk man-

43 Ibid.
44 Westrum (1988).
45 Dekker, Hollnagel, Woods and Cook (2008), p. 2.
46 Ibid.
47 Hollnagel, Woods and Leveson (2006), p. xi.

agement may be considered an innovative perspective. The discussions about this concept still take place primarily on an academic level. In organisations, resilience is hardly implemented; only forerunners experiment with it.

But others watch the developments with interest. We expect that once the concept has been operationalised more widely, implemented in the real world and has proven added value in terms of reduction of safety incidents, it will overthrow many of the theories and other 'truths' as described earlier in this chapter. Therefore, we refer to resilience engineering as potential future success.

2.1.2.7 Safety I versus Safety II

The last concept presented here is closely related to resilience engineering and is titled 'Safety I versus Safety II.' This concept by Hollnagel was first published in 2004. In short, the difference between Safety I and Safety II is that in Safety I mode, the focus is on 'things that go wrong' and that in Safety II mode the focus is on 'things that go right.' This is also clearly explained by Dekker. [48] This approach arose from the fact that the far majority of operational activities are successful. Only a very few activities result in safety incidents. But it is also known that people play a key role in the success of those operations and often that is because they have the required skills, knowledge and adaptive capacity to act in unanticipated situations, not foreseen in work instructions, procedures, or protocols. Then, professionals, who know how to prevent escalation, by non-prescribed, maybe even forbidden, creative interventions, may solve the problem and ensure undisrupted continuation of the operational process. This happens often in operational practice and is, in many cases, considered common practice. In actuality, this reality is created by the gap between leaders who are disconnected from work floor level and the operators who experience operational hiccups as part of their daily reality. Dekker refers to this phenomenon as "Work as Intended versus Work as Done", also known as WAIWAD.[49]

With respect to organisational learning, the common practice of 'unexpected' interventions preventing process disruptions embodies a wealth of information about where system design and formal operational procedures fail. Because of the ratio between these interventions and actual safety incidents, there is much more to learn by questioning why things go right than by investigating why things go wrong. The Safety II concept supports this view and aims primarily at improving operational reliability (read: reducing safety risks) by questioning why things go right. But this does not imply that investigations into the causes of safety incidents should be abandoned, but finding the reasons behind 'unexpected' interventions is considered a much richer and relatively easy-to-access source of information. In order to enhance an organisation's Risk Reduction Capacity, leaders might consider enhancing the use of this source of information to the optimum level.

48 Dekker (2006b).
49 Ibid.

2.1.3 *Personal safety versus process safety*

Historically, much attention is paid to personal safety, which, as maximum consequence, may lead to relative perishable injury or minor material damage; the related incidents are generally referred to as 'slips, trips and falls.'[50] These personal safety risks are easy to imagine and have a relatively simple deterministic cause and effect logic. The risks related to this type of incidents are relatively easily to be assessed and managed locally by general employees who know the risk-generating processes by heart and understand how to deal with these. And sometimes they are just not lucky enough.[51] Where general employees lack the awareness, knowledge, or skills to responsibly deal with these individual safety risks, they may be supported by safety professionals who have specialist know-how about these risks and the expertise to know how to control or manage these individual safety risks. Managing these types of risks is relatively simple.

Many safety-climate studies concern 'occupational safety' as the subject of the research undertaken. With respect to this topic, Cheyne et al.[52] offer some detailed examples of what they refer to as 'common hazards'; forklift vehicle movements, using compressed gases, slipping and tripping, working with hazardous substances, electrical hazards, etc. But people are less focused on occasionally appearing process disturbances, called major incidents, potentially affecting the fundamental values of the organisation.[53] The personal safety incidents, as mentioned above, are created by a different type of risk than major incidents are. Major incidents are related to the relative major hazards, which are generated by the primary processes of organisations. In this respect Reason mentions that the latter are "comparatively rare, but often catastrophic."[54] These major incidents are "less 'normal'; even exceptional and, in the minds of people not expected to 'really happen'."[55] This is one reason why these mishaps are not on employees' day-to-day awareness agendas.[56, 57]

The difference between low or high impact incidents is not determined by the complexity of the processes involved, but by the potential energy available to cause serious harm in combination with the vulnerability of the object threatened.[58, 59] Major incidents are the consequences of high potentially strong disturbances of primary processes, and are seldom unilaterally created at the work floor level. Also, the making of a major incident is a process which does not follow predetermined pathways.[60] Often Heinrich's

50 Onderzoeksraad voor Veiligheid (2007).
51 Groeneweg (1992).
52 Cheyne, Cox, Oliver and Tomás (1998), p. 259.
53 Onderzoeksraad voor Veiligheid (2007).
54 Reason (1997).
55 Perrow (1999).
56 Bratspies (2011).
57 Wagenaar and Groeneweg (1987).
58 De Vries, Verhoeven and Boeckhout (2014).
59 Fischhoff and Lichtenstein (1984).
60 Rosenthal (2001).

deterministic domino theory does not apply here.[61] Major incidents find their origin in underlying processes, like the design of technical processes, installations, machinery, equipment and the like, design of business models, contracts between providers and clients, consequential production pressure and focus on client or hospital patient expectations.[62, 63, 64, 65] These underlying processes imply a continuous trade-off that challenges the safe operational envelope of the primary process. Here, the way leaders behave is of great importance; where do they place their priorities and 'how strong is their backbone'?

In this respect, Hollnagel presents his 'Efficiency-Thoroughness Trade-Off'-principle (ETTO), addressing the continuous conflict between producing in the most efficient way and managing safety risks to the optimum.[66] Dekker argues that our society has got ahead of our understanding how systems work and fail.[67] Perrow even advocates that such complicated technologies "should be abandoned", but he concludes that this is an unrealistic proposal, simply "because we have built much of our society around them."[68] Nevertheless, society has accepted the risk of advanced complex processes with the potential of e.g., hospital patients who die due to caregivers who do not comply with the hand hygiene protocol in order to save time;[69] trains that collide because trains are scheduled too tight to be able to transport more passengers per hour;[70] or offshore oil platforms that explode because the leaders decide not to apply readily available safety measures in order to compensate for time lost on earlier days.[71]

2.2 Risk management

2.2.1 *Defining risk*

Like the multiple views on the definition on safety, there are different views on the definition of the term risk. In 1662, Arnaud formulated the essence of risk as: "Fear for damage must be proportionate not only to the severity of the damage, but also to the probability that the damaging event occurs."[72] Ale refers to a definition, used by many: "Risk is a combination of consequences and probabilities".[73] Willett defined risk as "The objectified uncertainty regarding the occurrence of an undesired event".[74] The shortest definition

61 Heinrich (1941).
62 Onderzoeksraad voor Veiligheid (2007).
63 Dahle, Dybvig, Ersdal, Guldbrandsen, Hanson, Tharaldsen and Wiig (2012).
64 Dekker (2011).
65 Reason (1997).
66 Hollnagel (2009).
67 Dekker (2011).
68 Perrow (1999).
69 Pittet, Hugonnet, Harbarth, Mourouga, Sauvan, Touveneau and Perneger (2000).
70 Onderzoeksraad voor Veiligheid (2013c).
71 Flournoy (2011).
72 Ale B.J.M. (2012).
73 Ale (2009).
74 Willett (1901).

is by Knight: "Measurable uncertainty".[75]Yoe describes 'risk' as "a measure of the probability and consequence of uncertain future events"[76] and he describes the equation of Risk=Probability x Consequence as a mental model to help people think about the elements that are required to create a risk.

Safety professionals, in general, apply the term 'risk' in different ways, but overall, they follow one generic logic: risk is the probability of the occurrence of an event, combined with the potential severity of the consequential damage.[77, 78, 79, 80, 81]

The international standard for risk management (ISO 31000) defines 'risk' as the 'effect of uncertainty of objectives'.[82] This definition is complemented by notes, stating that:

1. An effect is a deviation from the expected. It can be positive, negative or both and can address, create or result in opportunities and threats;
2. Objectives can have different aspects and categories and can be applied at different levels;
3. Risk is usually expressed in terms of risk sources, potential events, their consequences and their likelihood.

Beck argues that risks are 'latent side effects of production'.[83] This scholar views risk from a social perspective and concludes that "…the social effect of risk definitions is [therefore] not dependent on their scientific validity".[84]

Holzheu and Wiedemann who argue:

> Risk is all in the mind. That is to say, risk is (also) a notion of observation and not just an object to be observed. As a notion of observation, it is a kind of lens trough which we see the world. What we see as a risk is not absolute reality, but instead depends on the kind of lens and the way we look through it. Different disciplines use different kinds of lens and so they may see different things even when looking at the same object.[85]

A frequently used method to broaden people's perspectives on risk, is to present quantitative risk estimates of a certain risk under public discussion (e.g., the construction of a new rail road, using robots in the hospital's operating theatre, expanding an industrial area) and compare this quantitatively with other risks that are known to be generally accepted by the public.

75 Knight (1921).
76 Yoe (2012).
77 Cauwenberghs (2013).
78 Fischhoff and Lichtenstein (1984).
79 Ale B.J.M. (2012), p. 28.
80 Oostendorp, Zwaard and van Gulijk (2013).
81 Soree (2007).
82 International Standards Organisation (2018).
83 Beck (1986), p. 19.
84 Ibid. , p. 32.
85 Holzheu and Wiedemann (1993), p. 9.

About this method Slovic argues: “Even though such comparisons have no logically necessary implications for acceptability of risk, one might still hope that they would help improve people’s intuitions about the magnitude of risks.”[86]

About judging the potential effects of risk, Lauder proclaims: “Within normal chaos we should always think of such judgements as being an educated guess (where some are more educated than others) rather than being a scientific judgement.”[87] And in his contribution to the discussion, Hollander argues that risk is not a universal quantity – it is a social construct, a formula, compiled and adjusted over time, which enable us to cope with the day-to-day threats and uncertainties.[88]

According to Fischhoff et al. risk calculations are conditional and context dependent, because decision makers use different rules, believe different information, or consider different options. From that perceptive, we argue that the quantification of risks, as referred to by some of the scholars above, is not a reliable operation. These authors also conclude that it is not possible to define a universally acceptable risk level.[89]

Based on these different statements we conclude that there is no universal agreement among scholars regarding the definition of risk. We will therefore not claim an unambiguous definition of ‘risk’. Instead, in this dissertation, with the abovementioned statements and the scope of this research project in mind, and only as a landmark-term to facilitate communication in this dissertation, risks are understood as: *Unintended and uncertain side effects of primary processes with the potential to generate unsolicited consequences*.

2.2.2 *Risk management theories*

A structured process for managing risks according to the international standard for risk management (ISO 31000), the process of risk assessment and its implementation with respect to the scope of this study, form the structured globally accepted standard. This process contains the phases identification, analysis and evaluation of risks and is of paramount importance for optimising the functionality of controls and defences. These five phases are embedded in a cyclic structure, which is considered a useful model to establish the effectiveness of risk management. As technical progress, operational experience and changes in time are of influence on the character of initially identified risks, a cyclic approach is broadly accepted to be more applicable rather than a linear one-off exercise.

In order to illustrate why ISO-structured risk management systems were introduced in organisations using safety-critical primary processes, we give an explanation of what went wrong during one of the most serious major incidents during the 20th century and how that resulted in the initiation of a structured safety management approach.

86 Slovic (1987), p. 285.
87 Lauder (2015), p. 138.
88 De Hollander G. (2012), p. 58.
89 Fischhoff, Lichtenstein, Derby, Slovic and Keeney (1983).

On July 6th of the year 1988, a major incident occurred on the oil production platform Piper Alpha, which was situated in the Southern North Sea offshore Scotland. This event, resulting in 167 casualties, has been the worst disaster in the oil and gas industry. The case was investigated by an investigation committee chaired by the Honourable Lord Cullen. That committee published their report in October 1990. This report contains 106 recommendations including the recommendation that "The operator (read: oil company) should be required by a regulation to submit to the regulatory body a safety case in respect of each of its installations …" (Recommendation #1). In the report it is further explained what is expected of the contents of such a safety case; the document "… should be a demonstration that the hazards of the installation have been identified and assessed and under control and that the exposure of personnel to these hazards has been minimized …" (ref.17.37) Reference is also made to the role of management and management systems, in a way not described before in the UK oil and gas industry: "… safety is crucially dependent on management and management systems …" (ref. 17.36)[90]

The Piper Alpha major incident changed the world where it concerns the structured management of safety risks. The 'Cullen Report' may be considered the trigger for development of this structured and auditable approach in risk management. The meticulous description of what is expected of operating companies, as the main responsible parties in the industry, regarding their efforts in risk management, served as a basis for a global change in how safety management systems (read: risk management) should be structured. The Cullen recommendation for a more structured and system approach to manage safety risks initiated an innovative view for how to deal with organisational risk in the entire major hazard industry (thus also in the sectors included in this study) worldwide. During the years since the Piper Alpha disaster, the safety risk managing discipline has matured and a wealth of system models and sector-specific and generic risk management standards have been developed. Since then, various parties have worked towards the development of the 'ideal' structure of systems aimed at managing risks.

Structurally managing risks means following the steps of an iterative 'risk management cycle', which contains the elements of: risk identification, risk assessment, decision-taking, risk-reducing action, effect monitoring. This cyclic structure, in its simplest form, is represented graphically by a risk management cycle by Ale, presented below (Figure 3).[91]

90 Cullen (1990).
91 Ale B.J.M. (2012).

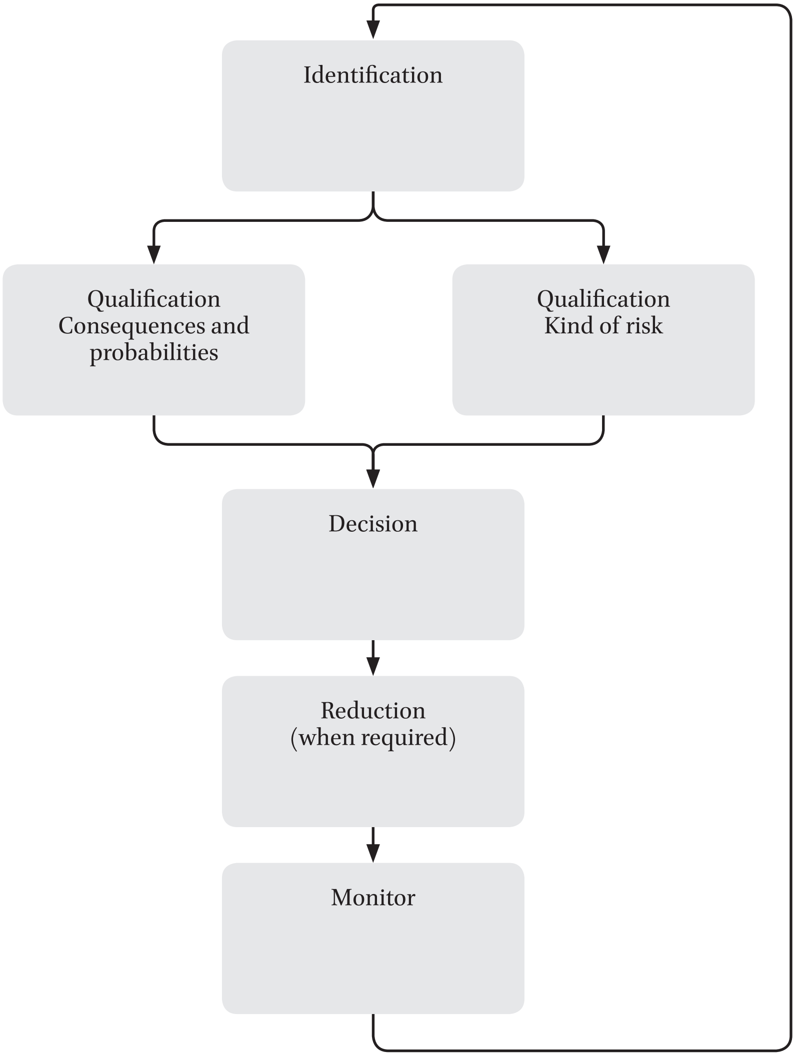


FIGURE 3 Risk management cycle (Ale, 2012)

This figure indeed contains all the principal elements of the risk management process and therefore it clearly shows the principles of cyclic risk management. However, for practical implementation, more detail is required. Following the principles of ISO 31000 risk management should be "systematic, structured and timely."[92] This structure also is found in the Australian and New Zealand Standard, AS/NZS 4360 as well in the Austrian version. Both standards were part of the source documents which evolved into the ISO

92 Purdy (2010), p. 883.

31000 standard.[93, 94, 95] So, according to these standards a structured process is necessary to conduct a risk management process. We find this in the outlines of the management models as issued by the International Organization for Standardization (ISO), and thus selected this international standard as the standard structure for our risk management framework.

2.2.3 *International principles and guidelines (ISO 31000)*

Regarding the development and standardisation of management systems, the ISO is considered the globally accepted authority. Many organisations have adopted the principal structures of ISO standards in the development of their individual risk management systems. Analogous to the conventional quality and environmental management systems design (ISO 9000 and ISO 14000), the structure of the international standard for risk management (ISO 31000) is based on an iterative/cyclic structure (Figure 4).[96]

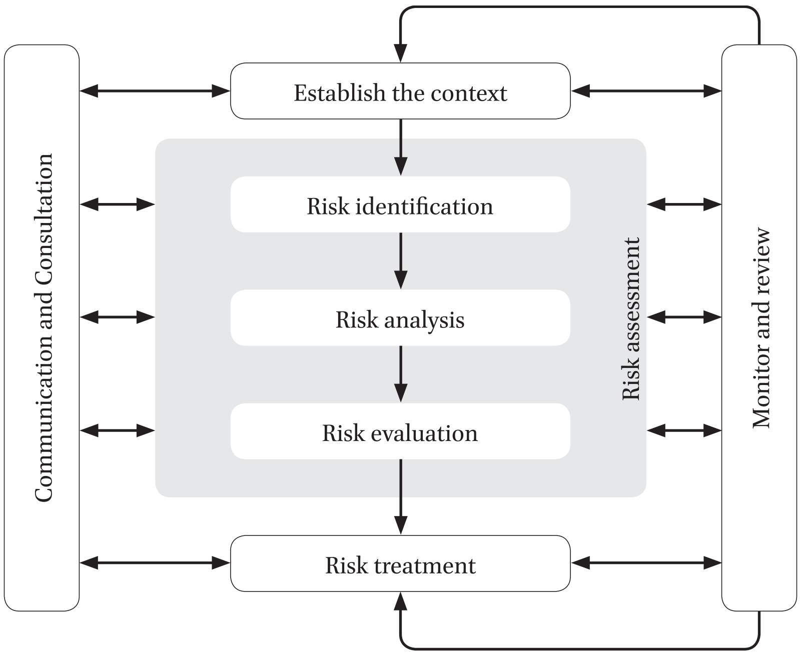


FIGURE 4 Risk management process (ISO 31000: 2009)

93 Standards Association of Australia (1999).
94 Austrian Standards Institute (2004).
95 Purdy (2010).
96 International Standards Organisation (2018).

In this figure, most of the basic elements as presented by Ale are included, but the process is extended by: 1. Establishing the context and 2. Communication and consultation.

'Establishing the context' represents what the organisation wants to achieve where it concerns the management of safety risks. Also, it determines the external and internal factors that may influence success in achieving those objectives.[97] In this step, an organisation declares what risk level is accepted and what measures have to be taken if the minimum acceptance level is not achieved. The step of 'communication and consultation' refers to ensuring involvement of internal and external stakeholders to understand their objectives and take their points of view and critical input into account when defining risk criteria.[98] Here the decision makers in organisations are forced to involve all stakeholders, including (or maybe even especially) general employees on work floor level, who are often exposed to the safety risks as generated by the primary processes. This way of working is considered an adequate procedure for achieving the ultimate result of effective risk management: current, correct and comprehensive understanding of its risks and that these are within its risk criteria.[99] From a legal point of view, implementation of the ISO 31000 guidelines is also supportive where it concerns compliance with the mandatory EU OSH Framework Directive 89/391, which directs organisations how to assess occupational risks.[100]

2.2.3.1 Risk assessment

For the argument of supporting risk management decisions, the need for assessing the safety risks generated by primary processes is strong. Apparently, potential sources of hazard may be latently embedded in operational systems, without anybody being aware and seemingly safe operations may contain latent failures (dormant hazards) for years, without developing into an accident.[101] The ISO 31000 guidelines on risk assessment aims to increase awareness of, and knowledge about hidden hazards. The core of the ISO 31000 model is formed by a group of three different, sequential activities: risk identification, risk analysis and risk evaluation. Despite the different nature of these activities, they are combined into one, highlighted, central block in order to emphasise their complementary function. These activities relate to each other as in a flow diagram; initially a risk is identified, then it is analysed and then evaluated. So, analysis and evaluation are sub-activities of identification and concern the same risk.

97 Purdy (2010).
98 Ibid.
99 Ibid.
100 EU OSH Framework Directive 89/391/EEC (1989).
101 Reason (1990).

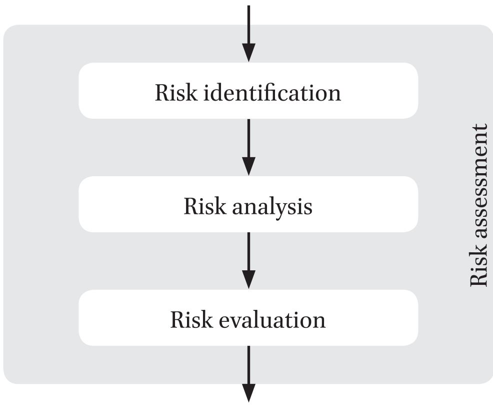


FIGURE 5 Risk assessment core of ISO 31000

This process deserves special attention as it represents the core activities required to make risks understood in the organisation. The responsibility to take risk-assessment decisions is typically a leader's task. But its purpose is to ensure that all relevant stakeholders are aware of and understand the potential impact of the identified safety risks and the envisaged control measures. Here leaders on all levels in an organisation must take their role-related responsibilities.

2.2.3.1.1 *Risk identification*

The initial activity of risk identification requires the application of a systematic process to understand what could happen, how, when and why.[102] The design of that process may be different with respect to the specific business sector and/or the type of risks to be identified (e.g., process safety vs. occupational safety). Most organisations identify risks on the basis of standard methods, for which application may be mandated by supervising authorities and/or certifying bodies. As examples, in organisations affiliated to the chemical process industry, internationally accepted methods, e.g., HAZID, HAZAN, HAZOPS, FMEA and relative ranking methods like the Kinney and Wiruth method for occupational safety (RI&E) are used. In the hospital sector, where entirely different risk situations apply, sector-specific translations of some of these risk-assessment procedures are developed, e.g., a modified version of FMEA, named HFMEA (*Health* Failure Mode and Effect Analysis) and a method named Prospective Risk Identification (PRI), based on RI&E is implemented.[103, 104] The identification phase may be considered the heart of risk assessment; risks which are not identified will not be analysed, nor evaluated, nor

102 Purdy (2010).
103 Pasman (2015).
104 Blok, Koster, Schilp and Wagner (2013).

reduced and consequently, remain uncontrolled as latent hazards; a major incident waiting for a trigger to happen. In organisations, safety-critical operating processes which contain the potential for major incidents to occur and in which much effort is put into risk identification, people are confident that 'the majority of serious risks' are known and controlled. But Motet et al. claim that this trust is unjustified and even is an illusion.[105] This claim is supported by the work of Taleb, who explains that safety-critical processes may generate unexpected events in which, during risk-identification sessions, the originating risks were not been disclosed; so-called 'black swans.' Regarding this subject he states that after unpredicted serious incidents, their origins are easily explained as these very unpredictable black swans.[106] The risk identification analyses performed in major hazard industries are not able to eliminate these black swans. A study by Suokas et al.[107] revealed six key problems that may affect the completeness and the quality of risk analyses; 1) a limited selection regarding which part of the primary process system and what kind of risks are to be included in a risk analysis, 2) limitations due to the selection of the process phase (normal or deviated operations) to be considered, 3) the selection of analysis method(s) to be used, 4) limited available resources (calendar time, workforce, finance), 5) limited available information and knowledge, and 6) discrepancies between written documentation and reality.

Lindhout et al. argue that "a significant gap exists between accident scenarios as foreseen by company safety management systems and actual scenarios observed in major accidents. The mere fact that this gap exists is pointing at flawed risk assessments…"[108] They further state:

> Safety managers and regulators, attempting to reduce and eventually close this gap, not only encounter the pitfalls of poor safety studies, but also the acceptance of 'unknown risk' as a phenomenon, companies being numbed by inadequate process safety indicators, unsettled debates between paradigms on improving process safety and inflexible recording systems in a dynamic industrial environment.[109]

They argue for a generally applicable scale indicating 'unknown-ness', analogous to the classification of safety incidents. They conclude that "… safety management can never be ready with hazard identification and risk assessment."[110] and they question "… whether any risk assessment will ever be complete."[111]

Lindhout et al. present a 'Knowledge/Awareness matrix' by Gowland regarding the

105 Motet and Bieder (2017)
106 Taleb (2010).
107 Suokas and Rouhiainen (1989).
108 Lindhout, Kingston-Howlett, Hansen and Reniers (2020), p. 1.
109 Ibid., p. 1.
110 Ibid., p. 1.
111 Ibid., p. 9.

proposed scale, classifying safety risks.[112, 113] Gowland classifies (un)known-ness by integrating knowledge of the risk and awareness by relevant people. This matrix is considered a relevant element in our research. We show this matrix below.

		Knowledge	
		Known	Unknown
Awareness	Known	Known Known	Known Unknown
	Unknown	Unknown Known	Unknown Unknown

FIGURE 6 Knowledge/Awareness matrix (Gowland, 2011)

As Lindhout explains: "In the resulting square the unknown may be at the awareness side, then requiring constant attention and keeping a sense of vulnerability. It may also be at the knowledge side, then requiring study. When both sides of a scenario are unknown, everything is needed, together with creativity and a pro-active approach around the question "what else?". Clearly this is not a vote for accepting unknown risk as a fact of life, nor for accepting it as a phenomenon which we would not be able to do anything about."[114]

In the most positive sense, risk analysts may know what can go wrong, but apparently the people charged with managing (or exposed to) the risks are not always aware.

Taleb argues that the human mind is subject to numerous blind spots, illusions and biases and that forecasting of the (non-)occurrence of major incidents is pseudoscience.[115] According to Taleb, history is opaque or non-transparent; the occurrence of events is observed, but we are unable to see the script creating these events. In this respect he describes the following 'Triplet of opacity': a. Illusion of knowledge about how things may happen, b. Retrospective bias by hindsight knowledge and c. Overvaluation of factual information, delivered by experts and authorities, which may not be true at all.[116] Due to this triplet (and the comfortable feeling it creates), we take seriously what

112 Lindhout (2019).
113 Gowland (2011).
114 Lindhout (2019), p. 848.
115 Taleb (2010).
116 Ibid., p. 20.

has happened and we ignore what could happen. As Taleb argues: "… we are wrongly concerned about past black swans and not about those that can happen, but which have not yet taken place."[117]

In organisations operating safety-critical processes, it is common practice to conduct a risk-identification process by brain picking in order to gather ideas about the possible causes of potential events. To this effect, groups of people (often experts, as well as experienced general employees) assemble in brainstorm sessions and launch suggestions about potential risk factors. But here 'illusion of knowledge' may act as a source for erroneous expectations; the retrospective bias depends on the individual history of the members of the group and people considered experts in their field or trade may overwhelm other people, who may have better ideas, but remain silent. With reference to this standard type of brainstorm, Kahneman[118] also suggests that this process may not lead to optimal results, as the more assertive people always will take the lead, after which other, less assertive group members adapt to the ideas as brought forward by the more assertive people.

Investigating causes of 190 incidents involving unwanted chemical reactions, Rasmussen[119] found that in 34% of the incidents insufficient knowledge contributed to the occurrence of the accident. With respect to his view on the completeness of risk identification, Perrow argues that: "… we shall see time and time again that the operator is confronted by unexpected and usually mysterious interactions among failures, saying that he or she should have zigged instead of zagged is possible only after the fact. Before the accident no one could know what was going on and what should have been done."[120] Referring to the major incident that occurred at Bhopal in 1985, Perrow[121] holds that:

> … our predictions about the possibilities of accidents and our explanations of them after they occur are profoundly compromised by our act of 'social construction.' We do not know what to look for in the first place and we jump to the most convenient explanation (culture, or bad conditions) in the second place. …

This is confirmed by Kahneman, who refers to our limited ability to imagine possible occurrences (e.g., events and their associated risks), which is restricted to what is present in our memory. This phenomenon is called 'availability heuristics' and in relation to this Kahneman claims that: "Information which cannot be retrieved (not even unknowingly) from someone's memory, might as well not exist."[122] Also, the more impact a certain event has had on us, the easier it is to retrieve this from our memories.[123] So, possible

117 Ibid., p. 148.
118 Kahneman (2012).
119 Rasmussen (1988).
120 Perrow (1999), p. 9.
121 Ibid., p. 359.
122 Kahneman (2012), p. 93.
123 Ibid.

risks that do not come to mind during risk-investigation sessions are not identified, analysed and evaluated. Or, as Kahneman suggests: "Taking into account information that does not come to mind, perhaps because we have never known it, is impossible."[124]

The limited level of control as reported by these authors, however, is a symptom of the mental imperfectness of humankind; many of us try hard, but apparently eliminating all risks is an impossible dream. In his graphical presentation of developments in the way we have attempted to prevent incidents, Groeneweg [125] introduced the so-called Murphy Margin (ref. 2.1.2.3), the area where people have no (more) control over the occurrence of incidents; if something *can* go wrong, it *will*.

After the statements and explanations by these referred scholars, we conclude that it is an illusion to think that we are able to ensure the safety of safety-critical operations to a level where all major incidents are prevented. But this knowledge about what we do not know, may not be a reason to limit our efforts in analysing the risks we *do* know.

2.2.3.1.2 *Risk analysis*[126]

The purpose of risk analysis is to obtain an understanding of the identified risk, including its envisaged consequences and the likelihood that these consequences will materialise. It is the leader's role to reach consensus between all parties, from top management to work force, about the acceptability of safety risks. Often governmental authorities have an approving role where it concerns the outcome of the internal risk considerations. The business continuity may be subject to a licence to operate, issued by these authorities. Thus, the leader who initiated the risk analysis process to be conducted is not only responsible for the health and safety of the people involved, they also have a responsibility with respect to the operational well-being of the organisation as well. For that reason, we elaborate on the subject of risk analysis here.

Leaders face serious uncertainties with respect to preparedness for unexpected operational disturbances (ref. 2.2.1). How can leaders define acceptability of risks and set priorities for risk management activities if the information they have about the potential magnitude of the consequences of a potential rare event is, at best, not more than a 'good guess'? On the same subject, Groeneweg argues that "the acceptability of risks is influenced as much, if not more, by subjective perception as by objective reality."[127] Groeneweg is supported here by the Scientific Council for Government Policy, which states: "Moreover, opportunities, risks and uncertainties can be valued differently by different social actors, partly because the nature of the perceived damage and the source(s) of

124 Ibid., p. 277.
125 Groeneweg (1992), pp. 3–9.
126 The ISO 31000 term 'risk analysis' relates to an activity which often is referred to as 'risk assessment'; for reasons of consistency within this thesis, we concur with the ISO 31000 terminology: we use 'risk analysis'.
127 Groeneweg (1992), p. 18.

threat can differ and because what are considered opportunities and threats need not be the same for every actor."[128]

How then do leaders motivate their subordinates when the organisation has operated flawlessly for a long time? According to Beck, the unreliability of assessing the acceptable level of risk is a logical result of the fact that risks are 'projected dangers in the future', implying that the centre of risk consciousness lies not in the present, but in an undefined future. He argues that "Risks can be legitimated by the fact that one neither saw nor wanted their consequences. Risk positions first have to break through the protective shield of taboos surrounding them and 'be born scientifically' in scientised civilisation."[129]

So, we conclude that the potential consequences of a safety risk can only be realistically established in retrospect, i.e., after the event and its actual consequences have materialised. This means that before an event has taken place, a decision about acceptability should always be considered 'a declaration of hope' based on subjective personal judgement, instead of a scientifically founded given. In that reality, leaders have to be able to align with their followers about the acceptability of safety risks and one approach is to follow internationally accepted risk analysis practices.

About this activity, ISO 31000 gives clear guidance how this understanding may be derived:

> Risk analysis can be undertaken with varying degrees of detail depending on the risk, the purpose of the analysis and the information, data and resources available. Analysis can be quantitative, semi-quantitative or qualitative, or a combination of these, depending on the circumstances. In practice, qualitative analysis is often used first to obtain a general indication of the level of risk and to reveal the major risks. When possible and appropriate, one should undertake more specific and quantitative analysis of the risks as a following step.[130]

This raises the question about the differences between these analysis methods and what may be expected of these three different types of analyses. In the following sections we will elaborate on that.

Quantitative Risk Assessment (QRA)

A quantitative approach presents risk levels in terms of mathematical units, which can be compared with other existing numbers in similar risk assessments and draw conclusions about acceptability of the calculated risk on the basis of a numeric outcome. The outcome of such calculation represents the probability of a certain major incidents occurring. This is a highly scientific exercise, which can be performed only by experts in situations where sufficient and adequate numerical reference and acceptance criteria

128 Wetenschappelijke Raad voor het Regeringsbeleid (2008), p. 2–3.
129 Beck (1986), p. 34.
130 International Standards Organisation (2018), Para. 6.4.3.

and/or history data are available. But in many situations this availability is not the case.[131] In this instance, the numbers cannot be related to relevant references and interpretation may not be representative within the specific context. This numerical approach, also referred to as QRA, is popular (and in many cases required by authorities) in high-risk technical settings and where assessment of environmental risks with respect to spatial planning is required; hence, technical experts are given a pole position in this process.[132] The QRA type of assessment work is often related to complex risk scenarios related to major safety (or environmental) incidents, which may affect people like local residents, who have no relationship to the source(s) of the risks other than that they happen to live in the area at risk. Here the difference in assessment of the risks between operational people who are potentially affected by the risks and the QRA experts, who are seldom part of that group, plays a role.

This coincides with a statement by Jungermann and Slovic, who argue that *probability assessment* is often influenced by the 'prominence' of an event and the extent of potential *damage assessmen*t is influenced by the 'context' in which an event may take place.[133] What may happen then is that the risk as assessed by these experts/scientists, may, based on their laboratory knowledge, contain questionable physical assumptions and even a naïve model of the part of society.[134] Here the word 'society' is to be understood as the people who are potentially exposed to the consequences of the risk at issue. This may be surrounding residents as well as employees/general employees of an industrial organisation or a group of patients in an hospital.

But, whatever the relationship between the risk-generating organisation and the potentially threatened part of society is, a scientific assessment of safety risks does not suffice to obtain a representative picture of the acceptability of those risks. For the sake of building trust and credibility, the initiators of the risk-assessment activities should always take a reflexive approach and involve the potentially threatened group in these activities from the design phase of the risk-assessment process.[135]

The lack of scientific rigidity in QRA is also referred to by Goerlandt et al., who conducted a study into theoretical views on validity and the validation of QRA. The purpose of their review was to discuss the claims made about QRA in relation to the available scientific evidence. Among other things, they concluded that: "Rejecting the claim that accurate risk estimation is possible, the cost-effective usefulness claim seems plausible, but very little evidence for this claim has been found."[136]

Last but not least: lay people may add unexpected value to the risk-assessment process as they come from different backgrounds, with different know-how/experience and they may see different aspects as they approach risks from a different perspective.

131 Van Asselt (2000).
132 Beck (1986).
133 Jungermann and Slovic (1993).
134 Beck (1986).
135 Ibid.
136 Goerlandt, Khakzad and Reniers (2017), p. 138.

Risk Analysis Matrix

In the previous section we discussed a purely mathematical assessment method, QRA, requiring scientific knowledge only available from specialised QRA experts. But in other risk situations where we feel potentially exposed to involuntary[137] safety risks, we also want to know our opportunities for exposure and then numerical references also communicate well. Apparently, people fancy numerical indicators. Numbers serve as satisfying references to indicate acceptability of risk levels. In this respect, the following mathematical formula is a very popular, globally used one: 'Risk=Probability x Effect.'[138] But how do you quantify these three conceptual qualitative units? There are different approaches to this, but a common practice, visualised by a so-called Risk Analysis Matrix, applies to all of these: in the matrix, a numerical value is assigned to the intersection field of each qualitative category of likelihood and severity.

During the risk-assessment process, individual or, preferably group opinions about the potential of risk are collected, using qualitative terms (i.e., improbable, remote, occasional, etc. indicating the probability component and catastrophic, significant, moderate, etc. indicating the effect component). After all opinions have been collected and discussed, the qualitative results are associated with the relevant intersection fields. Implicitly the outcomes are converted into the numbers attached to the fields where most opinions are clustered. At that moment the assessment process has flipped from qualitative to quantitative terms. Then people can see the results of their opinions in terms of the potential impact of risks in numerical terms. The acceptability grade for this procedure is high; in practice people involved in this assessment procedure consider the outcome of this process as representative of the hazardous potential of the risks assessed. Finally, based on these convictions, leaders set priorities and take risk management-related decisions. The risk analysis matrix is depicted in Figure 7 below.

137 People feel perfectly safe when taking safety risks on a *voluntary* basis; we drive during dark hours on snow-covered roads to the mountains, where, on the next day, we head at a high speed down steep ski slopes (and some even outside the controlled areas); we do sky diving; kite surfing; dive into the deepness of seas; and we ride motorbikes for fun. However, the risks referred to in this thesis are all meant to be induced by others and of an *involuntary* nature.

138 Yoe (2012).

Risk rating = likelyhood x severity

Severity		1 Improbable	2 Remote	3 Occasional	4 Probable	5 Frequent
Catastrophic	5	5	10	15	20	25
Significant	4	4	8	12	16	20
Moderate	3	3	6	9	12	15
Low	2	2	4	6	8	10
Negligible	1	1	2	3	4	5
		Likelihood				

Catastrophic	STOP
Unacceptable	URGENT ACTION
Undesirable	ACTION
Acceptable	MONITOR
Desirable	NO ACTION

FIGURE 7 Risk Analysis Matrix (Numerical rating)

Based on this approach, different applications and models (e.g., Risk Analysis Matrix, Kinney and Wiruth) exist. Many organisations use this approach as a decision-making tool to determine reasonable surety about what problems can be expected and prepare themselves by setting priorities in taking risk management measures. However, different scholars reject the validity of the Probability X Effect 'formula', but the simplicity of this approach creates support, trust and credibility with lay people as well as organisational leaders, who require the outcome of this analysis to be a credible argument to support their priorities in risk decisions. In operational risk communication the formula is working well indeed, but scientifically, the method is a dangerous house of cards.[139, 140, 141]

139 Beck (1986).
140 Van Asselt (2000).
141 Cox (2008).

Layers of Protection Analysis (LOPA)

Another approach, which is often used in (chemical) process industries, is the concept of LOPA. The concept was taken from guidelines by the US Center for Chemical Process Safety (CCPS) on automation, issued in 1993. The initial known application of LOPA as analysis tool for the effectiveness of process risk protection was by Dowell, Huff and Montgomery in 1997 (the acronym was not yet used) and published in the CCPS guidelines in 2001.[142] The LOPA approach involves not assessing the level of risk, but measuring the effectiveness of barriers installed to prevent an uncontrolled release of energy, and/or to mitigate the consequences if prevention has not been successful. The concept of LOPA is connected to so-called barrier-based management (ref. 2.2.6.3). This means that it is to be applied after risk identification has been completed and decisions about the required types and effectiveness of barriers are to be taken, or have been taken.

A LOPA-analysis may address different independent layers of protection, from inherent process safety, to emergency response. These layers represent different process states, from basic process control in undisturbed operations, via alarms, shut-down systems, active damage mitigating (sprinkler, firefighting) systems, and passive damage mitigating systems (bund walls, zoning), to emergency response. LOPA focuses on the effectiveness and reliability of the different measures envisaged to prevent process upsets. They consider, for example, human factors, the rigidity of hardware, expected breakdown frequencies of equipment and automation, and (wireless) communication systems. LOPA is often applied in combination with a risk analysis method, called the Safety Integrity Level (SIL), which has been designed to identify the reliability and expected failure rates of process safety instrumentation components. The SIL concept encompasses a classification system with respect to the probability for failure, known as PFD (probability of failure on demand). The SIL classification of the components installed in a process installation is one of the aspects taken into account in a LOPA analysis.

The LOPA concept suffers from similar uncertainties as the previously discussed risk assessment concepts. In 2018, Van Dort, a Senior Inspector of Major Hazard Control at the Dutch Inspectorate of Social Affairs and Employment Ministry, conducted an analysis into the question of whether the LOPA method offers the ability to determine measures leading to the state of the art in technology, in a reliable and reproducible way. His conclusions, amongst others, were as follows: 1) The reliability and reproducibility of the LOPA methodology is insufficient, 2) The resolution of the LOPA parameters is insufficient, 3) The risk of one individual scenario does not reflect the real risk on the work floor.[143]

ALARP – ALARA Risk Analysis

By the ALARP and ALARA risk analysis methods the acceptability of risk is determined by defining the relationship between the level of risk and the impact of measures (in terms of money, time and trouble) required to reduce an 'unacceptable risk' to an acceptable

142 Pasman (2015).
143 Van Dort (2016).

risk level. This assessment method was initially developed by nuclear power related sectors and has been adopted by various other sectors and by different legislators.[144] This method recognises two options used to determine the acceptability of risk: a) as low as reasonably practicable (ALARP), where the potential energy in the system is expected NOT to be able to create severe disastrous consequences, and the practicability of reasonable risk-reducing measures is defined in relation to the required financial investment; here the financial limitation is the leading argument; and b) as low as reasonably achievable (ALARA), where the potential energy in the system is expected to have severe disastrous consequences and the effectiveness of risk reduction measures is considered important, regardless of the required financial investment; here the feasibility of reducing risks to an acceptable level is the leading factor.

The ALARP/ALARA concept introduces the idea of reasonableness, which opens the management door to the consideration of other factors like cost and social acceptability.[145] The ALARP level applies to e.g., processes like tank farms, railway operations, oil and gas operations, refineries, general hospitals, etc. The ALARA level applies to e.g., aerospace, general technology, nuclear power generation, etc. This concept is depicted in Figure 8 below.

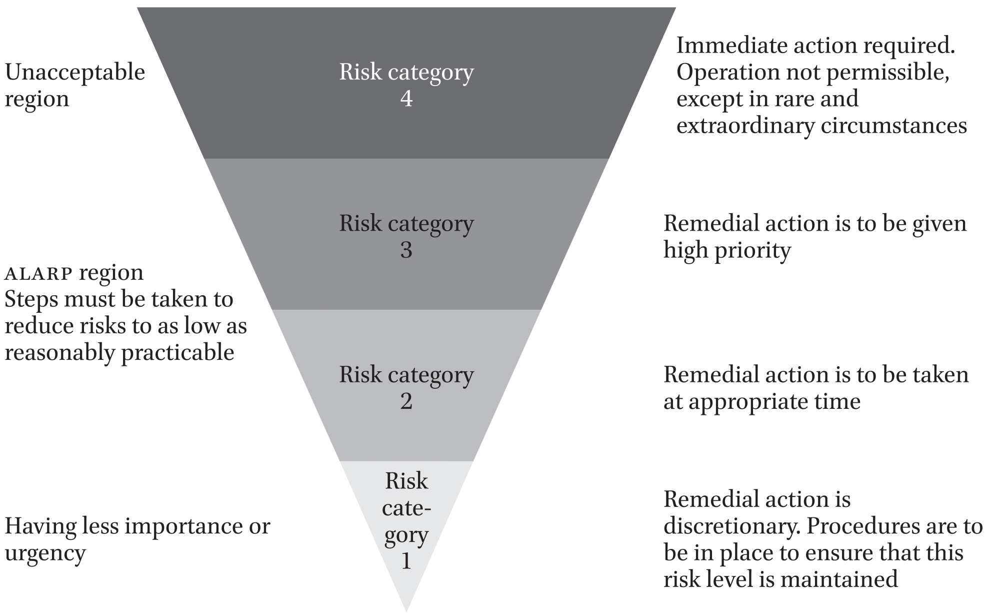


FIGURE 8 ALARP/ALARA Risk analysis method

In the ALARP/ALARA risk analysis concept, qualitative judgement prevails. There are no external formal criteria set; the leaders of the organisation concerned determine what a

144 This method has been proposed by Lord Cullen in the Investigation Report into the Piper Alpha disaster.
145 Yoe (2012).

reasonably acceptable situation is and what is not. Regarding possible criteria to consider in this risk analysis concept, Pasman refers to the Australian 'model Work Health and Safety Bill' in which the following aspects appear: 1. The likelihood of the hazard or the risk concerned occurring; 2. The potential degree of harm; 3. The skills/competences of personnel involved; 4. Availability and suitability of risk-reducing measures; 5. the proportionality of the required investment to manage the risk.[146]

Leaders may set acceptability standards for their specific operations and then initiate a risk analysis process, involving all stakeholders to identify the acceptance or rejection of conducting certain risk-reducing activities. But according to Slovic:

> … risk does not exist "out there", independent of our minds and cultures, waiting to be measured. Instead, human beings have invented the concept of risk to help them understand and cope with the dangers and uncertainties of life. Although these dangers are real, there is no such thing as "real risk", or an "objective risk."[147]

Operations involving intrinsic hazards are part of society as we have shaped it, however, and consciously or unconsciously, we have accepted the inherent risks in order to live life as we prefer it. As Perrow put it:

> … certain technologies should be abandoned and others, which we cannot abandon because we have built much of our society around them, should be modified.[148]

This touches on our individual needs and desires, which shape our expectations about the potential for a safety incident to be realised. These expectations depend strongly on individual imaginations regarding possible causes and effects, and the level of uncertainty we are ready to accept.

2.2.3.1.3 *Risk evaluation*

The international standard for risk management ISO 31000 reads:

> The purpose of risk evaluation is to assist in making decisions, based on the outcomes of risk analysis, about which risks need treatment to prioritise treatment implementation. Risk evaluation involves comparing the level of risk found during the analysis process with risk criteria established when the context was considered. If the level of risk does not meet risk criteria, the risk should be treated.[149]

After safety risks have been identified and analysed, organisations should decide how

146 Pasman (2015).
147 Slovic (2001), p. 19.
148 Perrow (1999), p. 4.
149 International Standards Organisation (2018), para. 6.4.4.

identified risks should be mitigated in order to meet a predetermined risk level. After remedial actions are completed, someone should measure whether the remedial actions have resulted in the desired result. The effects of remedial actions should therefore be compared with the initial risk criteria. This comparison offers an indication of the effectiveness of the risk management process. Conducting this comparison means the process feedback loop will be appropriately closed. Actually, this process can be considered a genuine management of change procedure. If the outcome of the feedback process reveals that remedial action has not resulted in a sufficient positive change, then more action is required to meet the intended risk level.

The Dutch Scientific Council for Government Policy (WRR) claims that the role of quantitative and semi-quantitative methods is limited; the council classifies these methods as a 'classical risk approach' and advocates a qualitative approach in which uncertainty plays a prominent role.[150] That alternative approach is described below.

2.2.4 *Vulnerability; an alternative view*

Knowledge is not equivalent to truth and certainty.[151]

We argued that a classical risk approach, as discussed in the previous sections, would impossibly lead to an assessor-independent, objective indication of the acceptability of risk. In that respect, the following approach, which does not identify risk as the multiplication of *probability* and *severity*, is of interest. It emphasises the *vulnerability* of the threatened object for certain threat(s).[152] Where threats can be defined, vulnerability can be taken as a point of engagement. Here the nucleus query is: "What defines the vulnerability of the primary process?" Attempts to answer this question do not focus on guesstimating the probability of occurrence of a predetermined event or quantifying the potential severity of such event. The emphasis is on the question "Where and how can things go wrong and what precaution and control measures are required and feasible to prevent this?" [153] In this approach, achieving an acceptable risk level is managed by focusing on the identification of control and protection measures based on imagined identified vulnerability for failure. Effectiveness (performance) is not measured by *output* indicators (e.g., incident frequencies), but by *input* indicators expressed in the degree of implementation of precaution measures.

Is this 'vulnerability approach' subordinate to the probability/severity approach? Not really, because the effectiveness of the probability/severity approach, measured by output indicators, depends on the reliability of the probability factor (taking for granted that the severity factor is reliably measurable by an objective rationale), and contains such a high degree of uncertainty and subjective reasoning that predicting a favourable outcome is considered to be no more than a bet.[154]

150 Wetenschappelijke Raad voor het Regeringsbeleid (2008).
151 Van Asselt (2000), p. 81.
152 De Vries, Verhoeven and Boeckhout (2014).
153 Ibid.
154 Ibid.

Van Asselt also recognises that risk perceptions differ among the various stakeholders e.g., scientists, safety experts, managers, operational workers, lay people and even the public potentially being exposed. Moreover, she identifies the problem that uncertainty violates the exactness of risk estimates and that the uncertainty *itself* is part of the determination of the level of risk. Therefore, she suggests that uncertainty and risk are interrelated on three levels: a) the uncertainty reality of what event may occur, b) the uncertainty analysis of assessing uncertain risks and c) the variability in evaluations of the uncertain risk analysis.[155] Following these suggestions, the model explaining the sources of uncertainty as developed by van Asselt is of relevance.[156]

This model shows two distinct, sequential types of uncertainty: uncertainty due to variability and uncertainty due to limited knowledge. Each level of uncertainty is 'fed' by different resources of uncertainty. This collection of resources ultimately results in two resources which feed the final limited knowledge; unreliability and structural uncertainty (Figure 9).

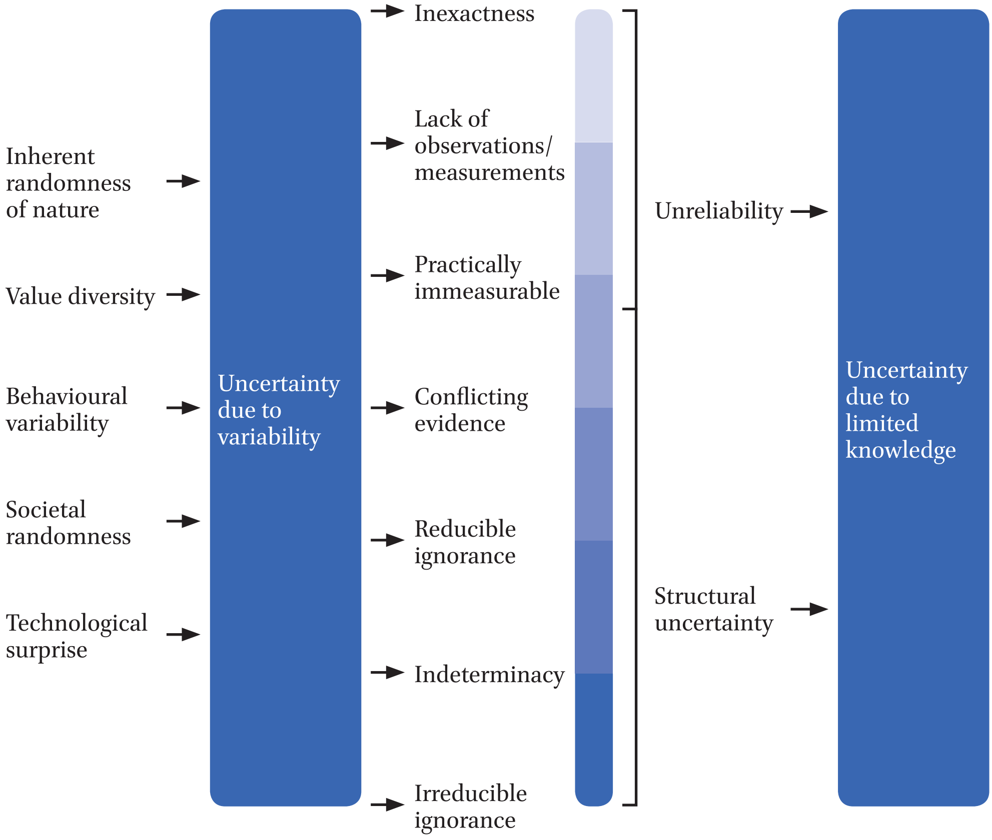


FIGURE 9 Sources of uncertainty (Van Asselt, 2000)

155 Van Asselt (2000).
156 Ibid.

This model is not yet a common approach in the sectors this study is about, but we argue that it could serve as an assistance to leaders in structuring their risk-assessment procedures.

Primary processes and their contexts, as well as the people involved (leaders and followers), are not static entities and may follow unpredictable paths. Uncertainty due to variability and limited knowledge are the biggest threats to the reliability of risk assessments.

Are we able then to quantify risks by using the 'vulnerability approach'? Not really, but why should we put effort into the presentation of subjective numeric values about an unreliable, imaginary concept? On this question the Dutch Scientific Counsel for Government Policy (WRR) has taken a clear stand: according to their advice to the Dutch Government, one should focus on *plausibility* instead of *probability*.[157] So the question is not about the *probability* of a major incident taking place, but about the *plausibility* that it may take place anyway. In this alternative view, a new approach presents itself: the 'precautionary principle.'

In fact, this is a philosophical change in the art of risk analysis, which shifts the risk analysis focus from deterministic, or probabilistic calculative causal thinking onto a focus on uncertain effectiveness of the implementation of the risk-reducing control measures. This alternative view originates from the environmental protection discipline that emerged at the end of the 20th century. Van Asselt explains that essentially uncertainty has two typical origins: process variability and lack of knowledge (ref. Figure 9). These sources can be specified by various sub-sources and they appear in different forms. All these different variances can be synthesised in the following general definition, raised by Van Asselt: "In sum, uncertainty can be defined as the entire set of beliefs or doubts that stems from our limited knowledge of the past and the present (esp. uncertainty due to lack of knowledge) and our inability to predict future events, outcomes and consequences (especially uncertainty due to variability)."[158]

This alternative view is not generally in use in the sectors this study is about. But in European legislation, the term 'precautionary principle' is explicitly referred to. A 'Future brief' by the Science Communication Unit of the University of Bristol (2017) offers the following explanation and definition:

> The precautionary principle is designed to assist with decision-making under uncertainty and is a core principle of EU environmental law, enshrined in Article 191(2) of the Treaty on the Functioning of the EU. The classic definition of a *precautionary approach* comes from the 1992 Rio Declaration on Environment and Development, which states that: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (UNEP 1992).[159]

157 Wetenschappelijke Raad voor het Regeringsbeleid (2008), p. 117

158 Van Asselt (2000), p. 88.

159 Science Communication Unit of the University of Bristol (2017), p. 3.

The precautionary principle is merely subject of discussion in the context of environmental protection and public health, but this does not restrict the legal application of the precautionary principle solely to these areas. To illustrate this, we quote some phrases of the 'Communication from the European Commission on the precautionary principle' below:

> Recourse to the precautionary principle presupposes that potentially dangerous effects deriving from a phenomenon, product or process have been identified and that scientific evaluation does not allow the risk to be determined with sufficient certainty.[160]

But agreement is still far away:

> The issue of when and how to use the precautionary principle, both within the European Union and internationally, is giving rise to much debate and to mixed and sometimes contradictory views.[161]

And:

> Proportionality means tailoring measures to the chosen level of protection. Risk can rarely be reduced to zero, but incomplete risk assessments may greatly reduce the range of options open to risk managers. A total ban may not be a proportional response to a potential risk in all cases. However, in certain cases, it is the sole possible response to a given risk.[162]

The message from Brussels is clear: the phenomenon of uncertainty and the precautionary principle are part of our legal reality. Legally speaking, this implies a principal change for leaders in the way they exercise their risk management responsibilities, however, the distance between Brussels and operations is still not bridged; according to the European Commission risks are to be measured and *thus* it must be feasible to do so.

2.2.5 *Discussion*

In the business sectors this study is about, the validity and applicability of different risk analyses methods is often subject to debate. With respect to this, Cox claims that there has been little research done to validate the effect of the use of matrices on the quality of risk management decisions. He suggests that this method shows the following limitations: 1. Matrices can assign identical ratings to very different risks by different factors of

160 European Commission (2000), p. 3.
161 Ibid., p. 2.
162 Ibid., p. 3.

probability and severity, while their multiplication produces the same outcome; 2. Matrices can erroneously show lower or higher quantitative ratings, depending the subjective judgement of the individual assessor. This, as Cox claims, can be 'worse than useless', leading to 'worse-than-random decisions'; 3. Allocation of resources of risk-reducing countermeasures cannot optimally be done on the basis of results of risk matrices; 4. Categorisation of severity cannot be made objectively for uncertain consequences: inputs as well as outputs are ambiguous.[163]

Quoting an insurance company that runs the risk of having to reimburse victims (individuals and organisations) after safety risks have developed into incidents: "Only risks that have been perceived can be identified and assessed, ignored or reduced and finally insured and reinsured against, or provided for in some other way."[164]

Also, no risk analysis does answer the question: "How safe is safe enough?"

The answer to this question is always: "It depends…." In order to be able to answer this question properly, it is of importance to make a distinction in the different types of possible events. Here the different nature between 'simple' incidents leading to relatively little injury or damage to the environment and major incidents plays a role. The idea that these 'simple' incidents happen more frequently than major incidents threatening the fundamental values of an organisation, has been considered a fact ever since Heinrich designed the first version of his 'risk pyramid' in 1931.[165] Apparently, we are better in reducing the risks potentially leading to major incidents, than we are able to prevent the less-serious operational disturbances that potentially lead to 'simple' incidents.

Following Tversky and Kahneman, this inability is even one of the reasons why low-frequency major incidents continue to occur. These scholars argue that people consider an event more likely to occur when they are better able to envisage its occurrence; and because major incidents occur with a relative very low frequency, their occurrence is more difficult to envisage. So, people are better able to recognise the signals indicating the development of relatively frequently occurring, 'imaginary', less-serious incidents, than they are able to judge the (weak?) signals of major incidents to develop. Moreover, Tversky and Kahneman argue that "… when faced with the difficult task of judging probability or frequency, people employ a limited number of heuristics which reduce these judgements to simpler ones …"[166] and "A person is said to employ the 'availability heuristic' whenever he estimates frequency or probability by the ease with which instances or associations could be brought to mind."[167] So, where the occurrence of an operational disturbance is difficult to imagine (e.g., because the assessing individual concerned has never experienced a similar situation), we avoid the difficult way of judgement and make life easier than it actually is. This implies that the effectivity of risk reduction depends on the leader's ability to imagine a certain major incident to occur, in which ingenuity is

163 Cox (2008).
164 Bayerische Rückversicherung Aktiengesellschaft (1993), pp. 7–8.
165 Heinrich (1941).
166 Tversky and Kahneman (1973), p. 208.
167 Ibid., pp. 207–208.

influenced by his or her individual knowledge and experience with respect to the safety risks involved. Moreover, referring to Tversky and Kahneman, Ronner[168] suggests that the following psychological factors: self-overestimation, optimism, herd behaviour, congruence, control illusion, wishful thinking, belief in authority, ostrich behaviour and transparency illusion, may also be of influence on the quality of risk assessment. Slovic et al. refer to another psychological factor that affects the evaluation of risk, called the 'affect heuristic.' They discuss the dominant role of emotions over rational argumentation and argue that:

> … people base their judgments of an activity or a technology not only on what they think about it but also on how they feel about it. If their feelings toward an activity are favourable, they are moved toward judging the risks as low and the benefits as high; if their feelings toward it are unfavourable, they tend to judge the opposite—high risk and low benefit. Under this model, affect comes prior to and directs, judgments of risk and benefit …[169]

This affect heuristic suggests a relationship between the expected benefit of an activity or technology, and the inferred risk level associated with it and vice versa. These suggested relationships are shown below (Figure 10).

168 Ronner and Ronner (2012)
169 Slovic, Finucane, Peters and MacGregor (2004), p. 315.

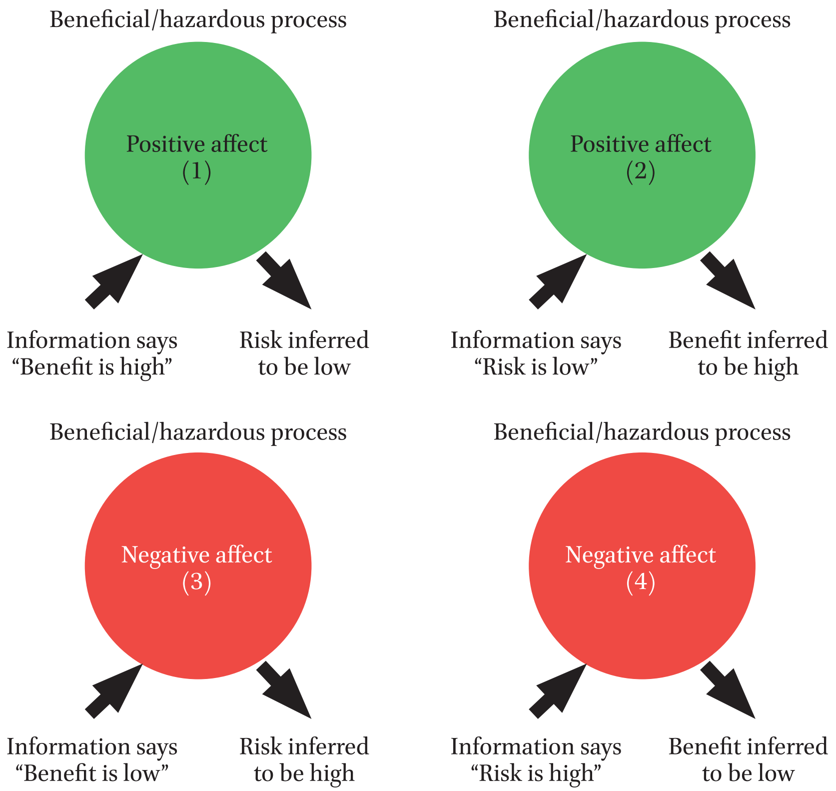


FIGURE 10 Affect Heuristic (Slovic, 2004)

Research by Slovic has shown that people not only judge risks according to what they *think* about them, but also how they *feel* about them; affect precedes and directs rational judgement.[170] Because risk assessment processes are strongly biased by the heuristics as mentioned above, they are by no means to be considered objectifiable processes.

Determination of acceptability of risk requires a broader view on risks at hand. Fischhoff et al. argue that in order to be able to assess whether the level of safety is safe enough, five generic complexities have to be solved: a) uncertainty about how to define the decision problem, b) difficulties in assessing the facts of the matter, c) difficulties in assessing the relevant values, d) uncertainties about the human element in the decision-making process and e) difficulties in assessing the quality of the decisions that are produced.[171] In their elaboration of these complexities, they mention some salient points: 1. Hazards begin with the human need the technology is designed to satisfy, 2. The decision of whether a risk is acceptable may be influenced by an individual who is relatively powerful, but who may be totally wrong, 3. Focus on one aspect that is consid-

170 Ibid.
171 Fischhoff and Lichtenstein (1984).

ered dangerous in the primary process, may encourage the neglect of other, even more dangerous hazards.[172] On this topic Hale argues as follows:

> There is still a further problem with the original definition proposed for 'danger.' This rests in the word 'potential.' This implies some predictable future state of the system in which harm occurs. If we wait long enough, all systems will wear out. Therefore, we have to make an arbitrary decision about excluding 'normal ageing' from our decision of harm to make it useful… We have to impose a restriction, which takes account of what is 'reasonable to expect', 'foreseeable', or 'credible' in order to exclude some (hopefully very low probability) future events, which are theoretically possible and so limit the range of future states of the system that we consider in assessing potential harm… In dealing with this area of very low probabilities we are in any case up against two fundamental limitations. First it is in all practical senses unprovable whether judgements of calculations of probability are accurate or not. We would have to wait too long to accumulate empirical evidence to prove whether failure probability was really one in 100.000 years or actually one in 10.000. Second, hindsight is not necessarily a good predictor of future probability of an event. We have to take into account that systems are goal directed and not totally deterministic.[173]

According to Muller, there is no unequivocal risk management model that can easily be explained after every application. It is always necessary to assess the specific risks, possibilities and limitations of risk management per organisation.[174] As mentioned by Hale, organisations are goal directed. This implies that a 'safest option' is not always the first priority of organisations. Beck supports that argument by suggesting that techno-economic 'progress'[175] is increasingly overshadowed by the production of risks, which he refers to as 'latent side effects' of the production process.[176]

Acceptable-risk problems are decision problems, requiring a choice among alternatives. That choice is dependent on values, beliefs and other factors.[177] Moreover, acceptability of risks is not an independent singular judgement of the potential effects of risks. It is also determined by a rather perverse 'cost-benefit' calculation in which both factors are uncertain. Therefore, in this acceptable-risk decision-making process, individual judgement by the leaders involved is a subjective operation. The many uncertainties, hidden behind the seemingly clear calculations of QRA as introduced by the several different subjectivities as mentioned in this section, open the fair possibility that certain risks are considered 'acceptable', because the way they are managed is the 'preferred' option in-

172 Ibid.
173 Hale and Glendon (1987), pp. 10–11.
174 Muller E.R. (2012b).
175 Inverted commas by Beck.
176 Beck (1986).
177 Fischhoff and Lichtenstein (1984).

stead of the 'safest' option.[178] In that respect Hollnagel argues that in risk management we face a dilemma of conflicting goals, which he labelled as the ETTO-principle, the 'Efficiency-Thoroughness Trade-Off.'[179]

Van Asselt argues that it is an illusion to think that risks can be calculated and that it is therefore a technical issue.[180] In this insight, Van Asselt is supported by Tversky and Kahneman, who argue:

> Most important decisions men make are governed by beliefs concerning the likelihood of unique events. The 'true' probabilities of such events are elusive, since they cannot be assessed objectively. The subjective probabilities that are assigned to unique events by knowledgeable and consistent people have been accepted as all that can be said about the likelihood of such events. Although the 'true' probability of a unique event is unknowable, the reliance on heuristics such as availability or representativeness, biases subjective probabilities in knowable ways.[181]

On the same subject Lauder argues: "Within normal chaos we should always think of such judgements as being an educated guess (where some are more educated than others) rather than being a scientific judgement."[182]

In general, risk analysis studies showing the calculated 'magnitude' of risks meet limits.[183] This is not only because the various quantitative risk-calculation techniques are not alike and do not produce identical analysis results, but also because personal, psychological, social, cultural and political factors are to be included in risk judgements. Quantitative risk analysis techniques do not comprise these socio-technical elements. These inconsistencies result in analyses which are incomplete and have a negative influence on the ability of organisations to define effective safety-incident-prevention strategies.[184] Assessing the potential impact of risks is a subjective process, which impossibly can lead to an objective, assessor-independent assessment, because who decides "How safe is safe enough?"[185]

This question specifically applies to major incidents of which the probability is known to be low, but we do not know just how low; here history data are scarce and by its very nature not useful from one to another case. Moreover, the usefulness of analysis of very small probabilities is questionable. Fischhoff et al. conclude that "no one solution to acceptable-risk problems is now available, nor is it likely that a single solution will ever be found…, they recommend "…to acknowledge the limits of currently available ap-

178 Ibid.
179 Hollnagel (2009).
180 Van Asselt (2012).
181 Tversky and Kahneman (1973), p. 231.
182 Lauder (2015), p. 138.
183 Wetenschappelijke Raad voor het Regeringsbeleid (2008).
184 Cox (2008).
185 De Vries, Verhoeven and Boeckhout (2014).

proaches and expertise…, and …improve the use of available approaches and… develop guidelines for their conduct and review."[186] In particular, conversion of qualitative terms into numerical values is a weak component of quantitative and semi-quantitative risk-assessment procedures.

Groeneweg puts things into perspective, and argues: "The acceptability of risks is influenced as much, if not more, by subjective perception as by objective reality; a situation that may frustrate some engineers and managers but cannot be discounted."[187]

2.2.6 *Risk management concepts*

How a future safety incident will develop is difficult, if not impossible, to determine; only in hindsight we can analyse how it happened.[188, 189] In this obscure and unexpected reality, leaders lead their people in their daily operational processes. Society expects these leaders to ensure these processes proceed in a smooth way and that safety incidents will be prevented.[190, 191, 192, 193] The process intended to prevent safety incidents is called *risk management*. In operational terms, this process aims to prevent unanticipated disturbances in the regular primary processes of organisations. In the context of this study, this process encompasses all activities needed to identify and control the safety risks related to these primary processes in a timely fashion.

According to Pasman: "Hazards and their associated risks can be reduced by well-executed risk management."[194] Operational disturbances happen because the safety hazards threatening the primary processes are not properly controlled. It could be argued, however, that safety incidents have their function; after experiencing an incident, leaders realise that someone somehow failed to control the risks, and this experience often triggers a process with which to improve risk management methods, which sometimes leads to innovative, out-of-the-box solutions. This is not, however, the best way to learn and invent better risk management methods.

The following sections offer an overview of the most influential concepts, without which risk management would not have achieved its present level. This selection includes DuPont (commitment and compliance); Reason ('Swiss Cheese' Model); Unknown (Barrier-based risk model); and Rasmussen and Cook (Dynamic Safety model).

186 Fischhoff, Lichtenstein, Derby, Slovic and Keeney (1983), p. xiii.
187 Groeneweg (1992), p. 18.
188 Stockholm (2011).
189 Dekker (2006a).
190 Leistikow (2010).
191 O'Dea and Flin (2001).
192 Pilbeam (2014).
193 Wu, Chen and Li (2008).
194 Pasman (2015), p. 28.

2.2.6.1 DuPont

On invitation of president Thomas Jefferson, a French chemical engineer E.I. DuPont founded a gunpowder manufacturing plant near Wilmington (Delaware) in 1802. DuPont had a reputation as a respectable professional who recognised the process hazards of producing gunpowder very well. To show his commitment to safety, Mr. DuPont and his family decided to live in a house situated on the black powder fabrication site.[195] This decision is still considered an ultimate sign of trust in the safety of the company's operations. Mr. DuPont invested heavily in the continuity of his business and the safety of his employees through a safe construction of the plant. But he paid attention to organisational factors as well; the accountability for the safe operation of plant was well placed: with management and supervisors. In the year 1811 Mr. DuPont issued his first official safety rules. In 1911 Prevention of Accident Commissions were established within each department and employee safety programs were institutionalised. The company established its own safety standards around 1930 after which the number of accidents significantly decreased. But this trend only reflected the specificity of the DuPont safety efforts: reduction of occupational accidents by focusing on behaviours of general employees. Process safety proved to be a more difficult challenge, as the company kept facing some process-related major incidents: e.g., in 1815 (9 casualties), in 1818 (34 casualties), in 1965 (12 casualties, 61 injured, $50 million loss).

Nevertheless, notwithstanding these major incidents, records of individual accidents showed impressive improvements in occupational safety. This did not remain unnoticed by the outside world. Globally, the industry reacted very positively to this surprising achievement and despite the mentioned safety incidents, soon DuPont was considered the overall pioneer on safety and risk management. During the 1970s the company DuPont decided to share its safety knowledge and experience with the world and founded a separate consultancy company, DuPont Safety Resources (later renamed to DuPont Sustainable Solutions). Nowadays numerous industrial companies all over the globe have embraced the DuPont safety programmes, based on top-down management policies, leadership, management (read: leaders) as the ultimate responsible party for safety and individual accountability for all staff.

2.2.6.2 'Swiss Cheese' Model

In the year 1990 Reason published his book on human error. The original intention for the book was to provide an essentially cognitive psychological account of the nature, varieties and the mental sources of human error.[196] Based on the work of Rasmussen, Reason explains the skill based, rule-based and knowledge-based errors and the psychological mechanisms behind unintended slips, lapses and mistakes and he nuances the different

195 Klein (2009)
196 Reason, Hollnagel and Paries (2006)

types of violations.[197] In addition, Reason presents the 'trajectory of accident opportunity', showing the different roles of latent failures, psychological precursors and unsafe acts leading to the breach of 'barriers' or 'controls.'[198]

Later, this theory was combined and integrated with the so-called 'Swiss Cheese' model, which had its origin in 1987 by Reason during the writing of his book addressing the role of human error in operational disturbances.[199] This model is depicted in Figure 11 below.

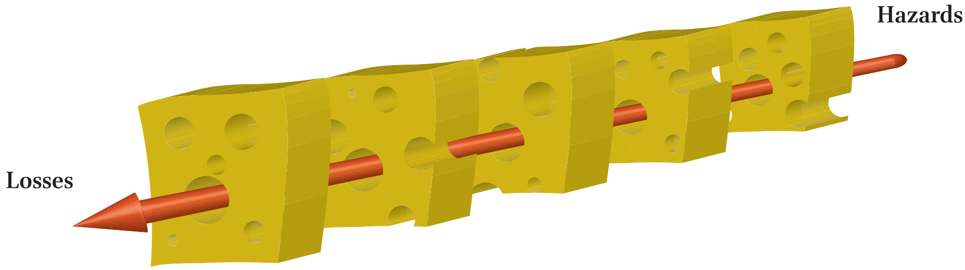


FIGURE 11 'Swiss Cheese' model (Reason 1987)

The 'Swiss Cheese' model has served as basic model for a concept called barrier-based risk management and, at a later stage, for a concept addressing cultural aspects of organisations, called Hearts & Minds.[200] This psychological approach of accident causation opened the eyes of many organisations to the unavoidable role of human error in the accident causation process.

2.2.6.3 Barrier-based risk management

This concept, suggesting that incidents are prevented by inserting preventive barriers between the *hazard* and an *event*, and that detrimental effects may be reduced using defensive barriers between events and *values,* was derived from the 'Swiss Cheese' model by Reason, in which the slices of the cheese represented the barriers; with or without weaknesses, represented by the holes in the cheese. This theory was operationalised by two tools: 1) a prospective pictographic risk identification model of operational disturbances, called Bowtie,[201] and 2) a retrospective incident analysis model, called Tripod Beta. Initially these tools were solely applied in chemical process companies and in the oil and gas industry, but barrier-based risk management tools later made their way into

197 Rasmussen (1983)
198 Reason (1990)
199 Ibid.
200 Van der Graaf and Hudson (2002)
201 The actual origin of Bowties is unclear, but Hudson suggests that a look-alike model of the concept, then called the Butterfly diagram, had been used in the 1970s by the chemical company ICI.

many different high-risk business sectors, including all sectors addressed in this research.

Figure 12 below is a Bowtie diagram showing the safety-incident process where the values exposed are potentially impaired by a hazard (or energy). This diagram includes controls and defences.[202] In situations where all barriers, controls and defences are missing or ineffective, the energy captured in the hazard, once triggered by a certain threat, will release in an uncontrolled way, and the operational disturbance (or incident) may take place and impair the values exposed.[203] If this is the case, then there has been an incident resulting in accidental consequences.

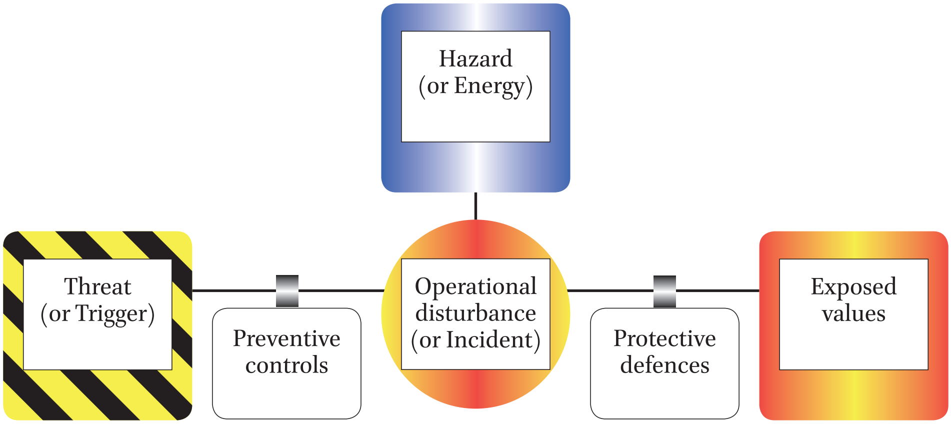


FIGURE 12 Bowtie diagram including controls and defences

The above diagram describes the incident process as a manageable or even controllable process. Proper risk management prevents operational disturbances or inhibits consequential damage (impairment of exposed values). Leaders and everyone else involved may feel safe and confident about the rigidity of the risk management measures taken, and trust the reliability of the implemented controls and defences. The longer an organisation operates free of accidental consequences, the safer everyone feels but 'no incidents' does not mean 100% safety, and feelings of safety do not represent the operational reality; wicked (unidentified or incorrectly assessed) safety risks and/or coincidence, may play a role and 100% certainty about the effectiveness of the measures taken is not realistic.[204] Barrier-based risk management tools facilitate organisations to identify preventive measures up to organisational culture level.

202 The figure uses one symbol to illustrate the concept of controls and defences. In a real major incident scenario, the diagram would probably show more different controls and/or defences.
203 Stichting Tripod Foundation (2015).
204 Yoe (2012).

2.2.6.4 Dynamic Safety Model

During the same period in time, Rasmussen and Cook published their Dynamic Safety model. This model shows that different organisational requirements act in different, sometimes opposite, directions as vectors in one integrated system. In order for an organisation to operate optimally, the leaders of the organisation are responsible for managing the different forces to an equilibrium where all forces are controlled.[205] This model is depicted in Figure 13 below. This model appreciates internal as well as external forces as part of a holistic system in which leaders are required to monitor and control the overall balance. In case any force causes an unbalance, the system's performance reduces and may end up in a (safety) incident. In this model the different, often incompatible, requirements of leaders of organisations as contributing factors in a safety incident development process are clearly presented.

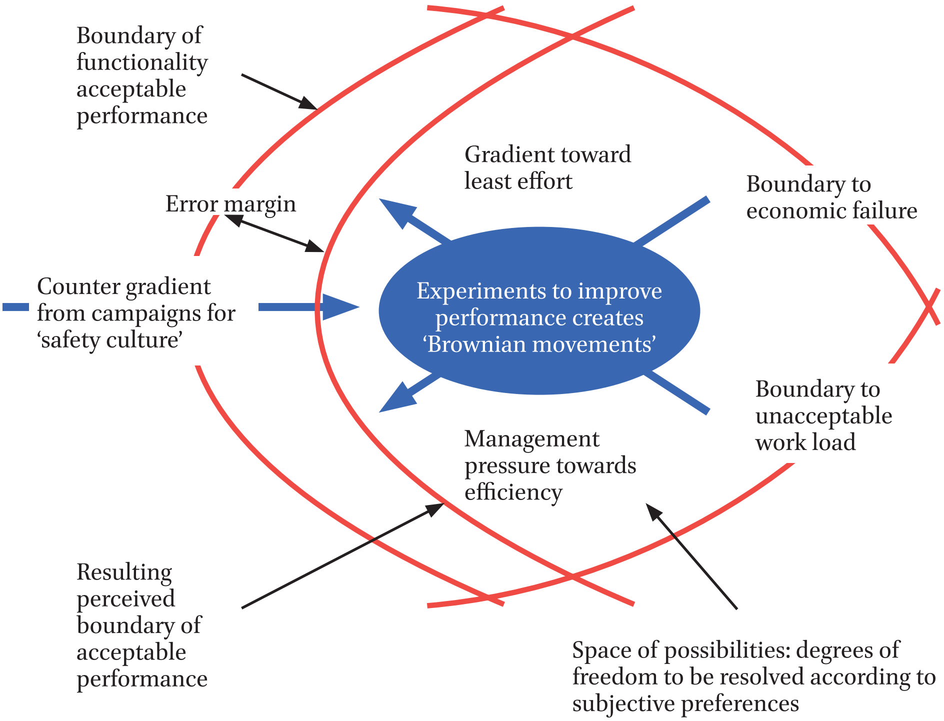


FIGURE 13 Dynamic Safety model (Cook and Rasmussen)

205 Rasmussen (1997).

2.2.7 *Risk reduction*

2.2.7.1 Risk reduction process

In fact, organisations are mechanisms for conversion or transformation (ref. 3.1). Conversion or transformation takes place by the design and operation of what is referred to as a process. Baguley argues that a process is a set of consecutive actions, stretching the path from a strategic decision to achieve certain objectives, to the actual accomplishment of those objectives.[206] This scholar suggests that in its simplest form, a process is characterised by three typical phases: inputs, conversion or transformation and outputs and that a process can be based on tangible and intangible objectives. Different processes may cover different inputs, objectives, conversions/transformations and outputs. Groeneweg has outlined a process where the quality of the working environment is defined as output.[207]

We concur with this latter suggestion and we argue that in a risk reduction process input, conversion/transformation and output can be specified as: input (the risks generated by the primary process), conversion/transformation (skills, knowledge, motivation and courage) and effect (the reduced risk level). With respect to the applicability for risk reduction processes, we translated conversion/transformation into risk reduction by intervening.

In this translation process, the 'Theory of Planned Behaviour' by Ajzen, the 'Behavioural Change model' by Balm, the Willing-Being-Able-Daring' framework by Elffers, as well as the work concerning 'Moral Courage' by Osswald et al. served as principal theoretical support.[208, 209, 210, 211] In the next paragraphs we elaborate on these theories.

2.2.7.2 Theory of planned behaviour (Ajzen)

The dynamics of the risk reduction process is located in the conversion/transformation phase. Only when this process is fully completed, will it be clear what remedial action is needed and can be taken. So, the effectiveness of the risk reduction process merely depends on the extent to which people take initiative and how and the extent to which they are able and willing to complete this process. Whether people are willing to participate in this process depends on three distinct factors: their individual attitudes, subjective norms and perceived behavioural control. These factors are the three motivating factors of the 'Theory of Planned Behaviour' by Ajzen[212] as depicted in Figure 14. This theory assumes that people's behaviour is steered by intrinsic (attitude and perception of behavioural control) as well as extrinsic (subjective norm) motivators. If we apply this theory to the risk reduction process phase where interventions take place, along with conversion/transformation, we see that all three theoretical factors are required to achieve the

206 Baguley (1994).
207 Groeneweg (1992).
208 Ajzen (1991).
209 Elffers (2014).
210 Balm, Spoelstra and Quak (2015).
211 Osswald, Greitemeyer, Fischer and Frey (2010).
212 Ajzen (1991).

desired effect (a reduced risk level). All factors contribute to the willingness of people to exhibit certain behaviour. The factor 'attitude' is required to motivate people to pay attention to the safety aspects of their occupational environment and their intrinsic motivation to intervene if safety risks present themselves.

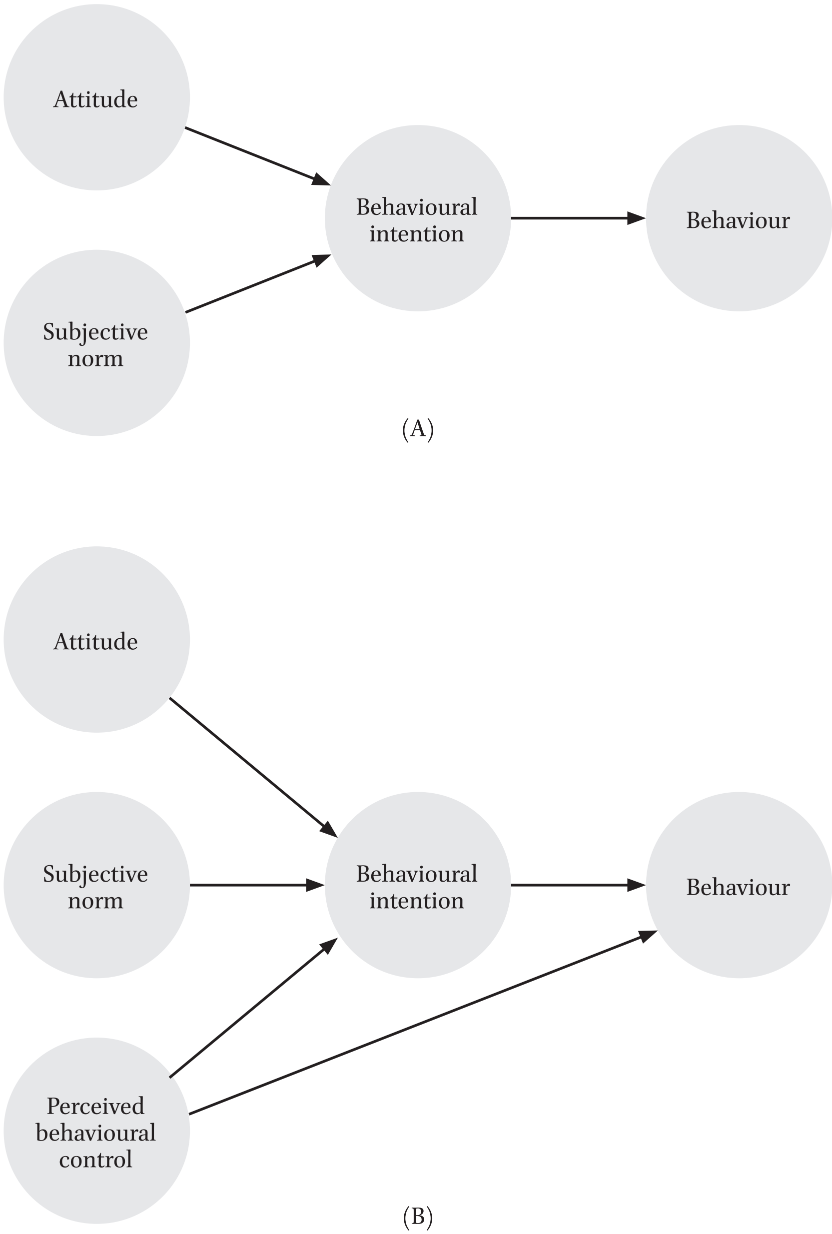


FIGURE 14 Theory of Reasoned Action (A) and Theory of Planned Behaviour (B)

The factor 'subjective norm' represents the individual's perception that their leaders and peers consider it 'normal' for an individual to take action when safety risks appear to him or her. The factor 'perceived behavioural control' steers self-confidence in people, by which they believe in their ability to intervene and dare to act. That courage to act is represented by the long arrow directly pointing from 'perceived behaviour control' to 'behaviour.' So, in order to induce the right behavioural intention and its consequential behaviour (a positive contribution to the conversion/transformation), all three factors are required and may empower each other, to ensure the correct interventions required to realise the reduction of safety risks are recognised.

Actually, this model is an expansion of the 'Theory of Reasoned Action', as developed by Ajzen in cooperation with Fishbein and initially published in 1975. This theory is, although often implicitly, widely used for the prediction of behavioural intentions and consequential behaviour. In 1985 Ajzen built upon this earlier theoretical model, by incorporating 'perceived behavioural control' as a third antecedent to behavioural intentions.[213]

2.2.7.3 Behavioural Change model (Balm)

In order to identify the Risk Reduction Capacity, we built on the Behavioural Change model presented by Balm[214] as depicted in Figure 15 below. This model contains some phases which are considered applicable to risk reduction as well. This applies specifically to the phases of: 2. 'Understanding', 3. 'Wanting to', 4. 'Being able to' and 5. 'Doing.' The phases 1. 'Receptiveness' and 6. 'Persevering' are considered as part of strategic decision-making and therefore not considered part of the operational risk reduction process itself. The phases 2–5 identify four specific elements which apply to the risk reduction process as well. In that respect we consider Phase 2. 'Understanding', as the phase in which people identify and evaluate risks. Phase 3. 'Wanting to', indicates the willingness/motivation of someone to create a change; in the context of risk reduction, we consider this as 'being motivated to intervene.' Phase 4. 'Being able to', indicates whether someone is in the position, sufficiently skilled and knowledgeable enough to do something; regarding risk reduction, we consider this as 'being able to intervene.' Phase 5. 'Doing', refers to actual execution of a required change; in relation to risk reduction this means actually performing remedial action after a risk has been recognised and people have intervened in order to create mitigation of the risk and action is taken.

213 Madden, Ellen, Ajzen and Bulletin (1992).
214 Balm (2002).

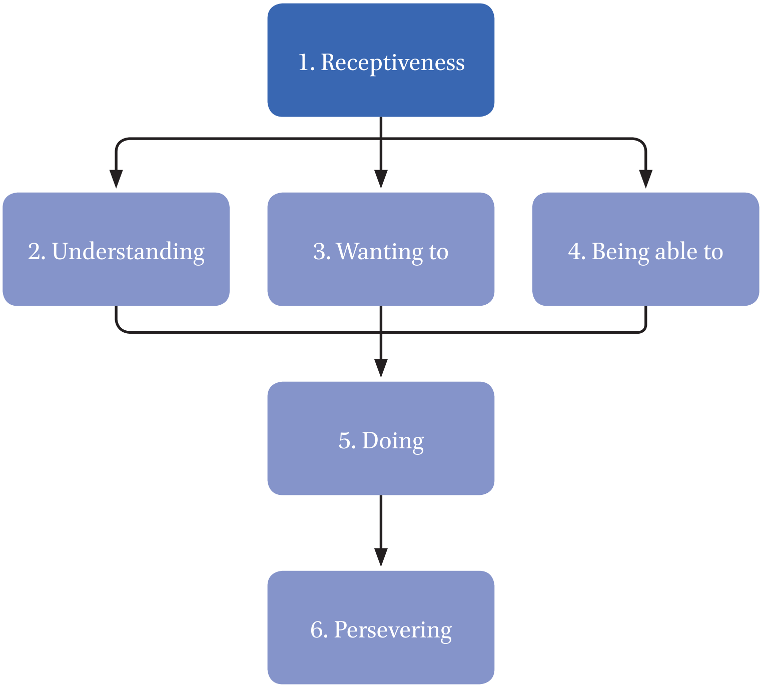


FIGURE 15 Behavioural Change model (Balm, 2002)

Interventions based on identification of safety risks are often needed at unexpected moments in time and, in many instances, are disturbing, possibly even annoying, to the operational process. By default, most leaders are not happy to see operational processes being disturbed. So, safety-risk-related interventions, are often considered as a nuisance by leaders who are responsible for the continuation of the operation. In that context a person who wants to intervene needs to be brave; they need courage to comply with their gut feeling. We therefore refer to the 'Willing-Being Able-Daring' concept by Elffers.[215] This concept resembles the model by Balm, where 'wanting to' and 'able to' are concerned, but Elffers' concept includes an additional element: 'Daring'. Daring reflects the fact that people who recognise risks and are able and willing to intervene, still have to dare to overcome a socio-psychological barrier, named 'courage'. Actually, reducing risk requires communication and physical intervention, sometimes even by interrupting operational processes. In this context courage relates to the phenomenon of 'moral courage'.

215 Elffers (2014).

2.2.7.4 Courage to intervene (Moral courage)

Interrupting operating primary processes means disturbing activities which are executed to achieve an organisation's fundamental goals. Intervening for safety reasons thus requires courage. Moral courage[216] is an essential behavioural property. The first option, taking action, is the result of a mind-set where safety prevails over other priorities. The second option is the denial option, where other priorities (e.g., the production process, career opportunities, peer pressure, etc.) prevail. Individual economic- or status-driven priorities may play a role here. Commitment is stronger and more individual than motivation; it requires courage to take unexpected action to reduce a safety risk. There is a wealth of academic work referring to the complexity of moral courage in the health care sector (especially related to nurses).[217, 218]

Also, Osswald et al. refer to 'moral courage' as a prosocial concept, which overlaps with 'bystander intervention', but is more broadly based. For a definition they refer to Lopez et al. (2003), who define moral courage as "the expression of personal views and values in the face of dissension and rejection and when an individual stands up to someone with power over him or her (e.g., boss) for the greater good."[219] In this respect we also refer to the work by Greitemeyer et al. (2006) who define moral courage as "brave behaviour accompanied by anger and indignation, which intends to enforce societal and ethical norms without considering one's own social costs."[220] Osswald et al. argue: "Moral courage shows certain similarities with heroism, because regarding the possibility of suffering serious physical consequences, moral courage and heroism overlap… when a person acts morally courageously, he or she runs the risk of negative social consequences such as being insulted by a perpetrator."[221]

Amos and Klimoski focus on courage as an act of leadership outside a formally designated role. In these situations, the choice of whether or not to act as a leader on the team is a discretionary choice and often involves risk. They argue: "We consider the qualities of a team member that make up the propensity for them to act like a leader in situations of risk where the choice to act is most problematic. We propose that what we know about the virtue of 'courage' lends valuable insights into this question and offer a framework of three qualities (character, confidence and credibility) that serve as the foundation for the construct."[222] Following the above referred scholars on moral courage, we conclude that there is no difference whether someone is formally assigned as a leader or acts as an informal leader on his/her own initiative. Where intervention aimed at prevention incidents is concerned, formal assignments don't count. In both settings, formal and informal leadership, moral courage is considered to be a virtue to be mastered. Sekerka et al. suggest

216 Osswald, Greitemeyer, Fischer and Frey (2010).
217 Murray (2010).
218 Bickhoff, Levett-Jones and Sinclair (2016).
219 Osswald, Greitemeyer, Fischer and Frey (2010), p. 3.
220 Ibid., p. 4.
221 Ibid., p. 6.
222 Amos and Klimoski (2014), p. 110.

that professional moral courage is a managerial competency. In their work they present five dimensions to be considered when moral courage is to be measured: moral agency, multiple values, endurance of threats, going beyond compliance and moral goals.[223]

2.2.8 *Discussion*

This overview of risk management related theories and concepts is by no means complete, but it represents the historical development from 1802 (DuPont) to the contemporary main body of knowledge about risk management. In this selection appears a trend from a workforce focused, top-down and compliance-driven policy (DuPont, Hellriegel), where workforce is considered a threat by their unsafe behaviours, to a psycho-sociological approach (Rasmussen, Reason, Groeneweg, Dekker, Hollnagel, Woods, Leveson and Weick), where employees are considered valuable sources of information instead of hazards to inherently safe systems. This overview illustrates that since the inception of risk management, the view on the role of operating people has shifted from 'causers' to 'solvers.' Also, the quoted concepts show an increased interest in the role of leaders. The development of risk management concepts has also influenced the relationship between leaders and general employees, the way leaders behave and how they attempt to cope with their own conflicting goal of production versus safety.

All concepts discussed in this overview are still in use. Some are used simultaneously and in parallel with other concepts, some organisations stick to one concept they strongly believe in. Risk management policies of organisations in some sectors may be more compliance based, other sectors may be in favour of more socio-psychological approaches, or even experimenting by conducting experimental pilot projects with resilience engineering and/or the Safety II concept. Nowadays, many risk professionals participate in discussions on risk management on the internet. Internationally renowned scholars participate in brainstorming and discuss innovative developments via the website www.safetydifferently.com.

Many, if not all, organisations have developed their own tailor-made risk management approach in which a mix of the different approaches can be noticed. An international group of risk management professionals/scholars has developed a so-called Zero Accident Vision and operate a 'Zero Accident Network.'[224] The objective of this group is to achieve totally safe organisations, where no incidents occur, or will not result in harming consequences. Whether this initiative will succeed is not agreed upon by everyone. For instance, Yoe claims that: "Virtually everything we do involves risk, and zero risk is unachievable."[225] So, a goal of 'zero accidents' may be useful as motivator, but it is still a dream yet to come true.

We take the position that with respect to the prevention of safety incidents there is no silver bullet yet, but in many organisations, improvement of the safety of primary

223 Sekerka, Bagozzi and Charnigo (2009).
224 Zwetsloot, Aaltonen, Wybo, Saari, Kines and De Beeck (2013).
225 Yoe (2012), p. 167.

processes is feasible, albeit in different sector/organisation specific ways, using different methods. For that reason, in this research different concepts are taken into account. Where in this research risk management is subject of discussion, these concepts are implicitly or explicitly contributing to our argumentation.

A lack of courage to intervene can trigger a safety incident. When people decide that safety is most important, and dare to intervene, we call them 'committed.' People who decide that other priorities are more important, and who refrain from action or leave the decision to others are considered 'irresponsible.' We argue that people's priorities are shaped a great deal by the way that leaders behave. The priorities of leaders are reflected in the priorities of their followers.

2.3 Leadership

The following sections offer insights into the different strategies that leaders can apply to inspire their followers to bring about the movement or change required to achieve intended operational results.[226] The term 'leadership' is defined in the first section, then we discuss leadership as a social construct, and outline the levels of leadership. The leadership process is discussed, the concept of a 'Leadership Moment' is introduced and elucidated, as are 'leaders', 'followers' and 'context'.[227] In the sections about behavioural motives, we give an overview of work by different theorists, with respect to three different motives (achievement, affiliation and power); here these terms are re-named Task orientation, Relation orientation and Self orientation. These sections conclude by profiling leaders, and we explain the behaviours that can be expected of differently oriented leaders. We argue that leaders can be profiled as being Task-, Relation- and/or Self-oriented.

2.3.1 *Defining leadership*

The term 'leadership' is defined in many ways. According to Yukl there is no 'correct' definition; any definition will do, as long as the wording increases our understanding of effective leadership.[228] His version of leadership reads: "Leadership is a word taken from the common vocabulary and incorporated into the technical vocabulary of a scientific discipline without being precisely defined."[229] Yukl couldn't resist offering more clarity about what leaders (should) do, however: "Leadership is the exercise of influence resulting in enthusiastic commitment by followers, as opposed to indifferent compliance or reluctant obedience."[230]

Ladkin claims that "… leadership's complete identity will necessarily always remain elusive."[231]

226 Pardey (2007), p. 15.
227 Winter (1991).
228 Yukl (2010), p. 21.
229 Ibid., p. 20.
230 Ibid., p. 22.
231 Ladkin (2010), p. 28.

Former US president Dwight Eisenhower explained leadership as: "The essence of leadership is to get others to do something because they think you want it done and because they know it is worth while doing."[232] This shows a clear top-down approach; the leader is the *commander*. Kotter puts his idea about leadership as follows: "Leadership is about coping with change."[233] Here the focus is not on the relationship between order and execution, but more on the leader as a *mediator*, who does his job in a situation subject to change. Pardey explains leadership as: "the ability to bring about change in a group or organisation, when there is risk or uncertainty, by inspiring others to head in a particular direction."[234] In this version, the leader is depicted as an *inspirator*.

Gabriel refers to the morality of leadership. In this respect, this scholar argues that: "Followers expect leaders to be competent just as they expect professionals and others; but they also expect leaders to provide moral leadership."[235] This he elucidates by suggesting that leaders are seen as 'good leaders' if they live up to moral (often unspoken, uncodified and even shifting) standards, which are considerably higher than the standards which we apply usually to most other people than leaders. Zaleznik argued that: "The net result of the leader's influence changes the way people think about what is desirable, possible, and necessary."[236] In his approach, the leader is a *motivator,* whose job it is to convince people to concur with the idea that working towards the common goal is good to do.

In these different descriptions of leadership, the leader is presented as the representative of leadership, acting as a commander, mediator, inspirator, or motivator. More different expressions are imaginable, but there is one commonality about these definitions: they all refer to 'creating change', where the objective of leadership is to change a less-desired situation into something more desirable. Creating change means: applying power, push and pull, tension and overcoming resistance to change a certain situation into a different one.

2.3.2 *Leadership as social construct*

Political leaders have been recognised as powerful influencers to humankind since history has been recorded. But notwithstanding their clear existence, the world did not bother to postulate 'leadership' as a specific notion. In a computerised search of 2.614 articles related to political science, appearing between 1906 and 1963, the words 'leader' or 'leadership' appeared only 17 times. Since 1977 this situation has changed and the notion of 'leaders' and 'leadership' have become commonplace, although many people and schools have different and sometimes conflicting, individual opinions about what these notions,

232 Eisenhower (1956).
233 Kotter (1999), p. 4.
234 Pardey (2007), p. 15.
235 Gabriel (2015), p. 316.
236 Zaleznik (1977), p. 71.

especially in situations of high pressure and stress, mean.[237] This may be the result of the fact that, compared with other linguistic terms these notions are relatively young. Apparently consistent views on leadership have not yet matured and one may question whether that ever will happen… In this respect it is not even realistic to expect global uniformity, because the interpretations of leadership depend a great deal on organisational and local/cultural characteristics. The way leadership is looked at shows that this phenomenon is an unequivocal container-notion, encompassing many different aspects, e.g., executing different tasks, using different styles, relating to different people with different attitudes, knowledge and skills, operating in different contexts. And these different factors also relate to the various different definitions in use.

Gergen explains the term 'social construction' as follows: "What we take to be importantly depends on how we approach it and how we approach it depends on the social relationships of which we are a part."[238] We suggest that at the very bottom of this situation lays the basic fact that 'leadership' is not physically visible nor graspable; it is not an object. So, in a particular context at hand, people may think and say about it what they consider right. Their meaning depends on to whom they talk and in what context this conversation takes place. From a philosophical point of view, 'leadership' is a phenomenon derived from social construction and this is probably a valid explanation for its lack of definitional edge.[239]

2.3.3 *Levels in leadership*

Above all, leadership is about the relationship between someone in a leading role and someone in a following role. The main objective of leaders is to *take decisions* which *inspire others to follow* in the desired direction in order to bring about *movement* in order to create a desired *change*. This means that pointing the desired direction to people is not enough; they must also be willing to *move*. About this Pardey[240] concludes that without movement, people are *just queuing.* The effectiveness of leaders in getting people to follow, is twofold: in the capacity of inspiring others and in the voluntarism of followership. His definition of leadership reads: "leadership is a bit like 'good art' – we may have difficulty in defining it, but we know it when we see it (or experience it)."[241]

In the scope of this study, anyone who demonstrates leadership, regardless of their hierarchical position in an organisation, is considered to be a leader. Since organisations are characterised by structures, such as hierarchies, sites, plants, departments, and so on, leaders operate at different organisational levels. We present three commonly distinguished leadership levels.

237 Post (2004).
238 Gergen (2009), p. 2.
239 Ladkin (2010).
240 Pardey (2007).
241 Ibid., p. 9.

Strategic level

Leaders assign the different tasks, manage the conduct of these tasks and lead the people involved to ensure achievement of the organisation's targets and objectives, (earlier in this section referred to as 'change') in a safe and secure manner. Examples of strategic leaders are: Managing Directors, CEOs, General Managers. These leaders are held ultimately responsible for ensuring that operations run as intended: efficient, undisturbed and safe.

Tactical level

On a tactical level, we find the direct reports of these strategic leaders (e.g., Division/Regional Managers, Financial Managers, Operations Managers, Technical Managers, etc.). These leaders are merely unit/department based. They operate according to their individual professional disciplines, as appropriate to the specific type of operations in their units/departments. They understand the processes, technology and procedures that apply to their units. Where applicable, they are able to discuss operational topics with general employees. Hierarchically, their place is in between strategic leaders and operational staff.

Operational level

Leaders on an operational level instruct and supervise the people who physically create the product/service which leads to the intended added value (earlier in this section referred to as 'change'). On this level, people are closest to and sometimes even exposed to, the safety risks generated by the primary process. Leaders on this level are called e.g., supervisor, shift leader, nurse in charge of the ward, team leader, etc. Operational leaders are expected to be aware of risks themselves and able to act (precautionary) to prevent operational disturbances, or (reactively) to mitigate the consequences of these events. Also, these leaders are expected to ensure that in their area of responsibility, operational workers are equally aware and are also able to prevent operational disturbances or mitigate any negative consequences. This is an implicit part of their job.

2.3.4 *The leadership process*

2.3.4.1 The Leadership Moment

According to Alvehus,[242] leadership is about the exercise of influence, it takes place in asymmetrical power relations, and is about striving towards a common goal; their purpose. The Leadership Moment model by Ladkin, discussed later in this section, also refers to this power momentum.[243]

Effectively leading people requires the right combination of personality, power and competence, executed in different formats and styles. Which format or style is used de-

242 Alvehus (2014).
243 Ladkin (2010).

pends on internal properties (e.g., the leader's individual characteristics or traits), as well as external properties: the individual characteristics of his followers as well as the contextual, organisational and/or situational characteristics.[244] The people being led are referred to as 'followers.'[245] These followers are considered to be people who work in the same organisation where their leaders work and where the relationship between leaders and followers is based on their relative hierarchical position or some other type of seniority.[246] Leaders may perceive the purpose differently from how their followers do. And so, it may be with respect to the context in which both types of actors operate. Leadership is not a constant; during the operational practice between leaders and followers, the nature and meaning of leadership is influenced continuously by the dynamics in context and the developing perceptions of the actors.

The sum result of these dynamics is depicted in a model called the 'Leadership Moment' as proposed by Ladkin (Figure 16).[247] Leadership may manifest itself differently, but "the common feature is collective mobilization towards an explicitly or implicitly determined purpose."[248] In this model, the interacting four fundamentals (purpose, leaders, followers and context) create the central entity 'Leadership Moment.'[249] This 'moment' is not a static 'thing', it represents the momentum induced by the social relations of the actors involved and its 'being' depends on their social, psychological, historical and organisational context.[250]

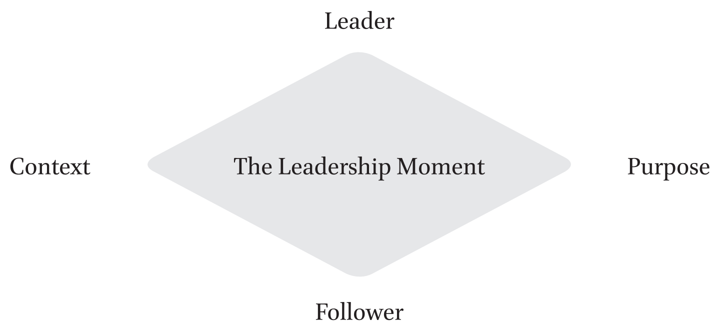


FIGURE 16 The Leadership Moment model (Ladkin)

The following paragraphs explain the notions of 'purpose', 'leaders', 'followers' and 'context'.

244 Yukl (2010).
245 In literature, to indicate followers the terms 'members' and 'associates' are also used.
246 Pardey (2007).
247 Ladkin (2010).
248 Ibid., p. 28.
249 Here the term 'moment' is not related to time, but it is used in relation to the meaning of 'moment' in a mechanical science, meaning 'momentum', like 'torque' or 'power.'
250 Ladkin (2010).

Purpose

In general, the purpose of an operation or process is ensuring an efficient and effective course of all activities required to achieve desired objectives. From the perspective of this study, the purpose of leadership is primarily to warrant that the organisation's primary processes are executed efficiently and free of safety risks which may potentially lead to safety incidents. A purpose, applied to the domain of risk reduction, requires a change process to be conducted in order to change a relatively high-risk situation into a less risky situation. Here we deliberately avoid the use of the term 'safe' in order to emphasise that risk reduction is not identical to elimination of all risks, known and unknown and optimal safety does not necessarily imply a zero-risk condition, because "you don't know what you don't know"[251] (also called: unknown-unknowns). [252, 253]

Leaders

The definition of a leader by Drucker is most concise and very relevant to this study: "A leader is someone who has followers."[254] However, often people refer to the difference between managers and leaders as quoted by Bennis: "Managers do things right and leaders are people who do the right thing."[255] Kotter argues that leaders differ significantly from managers, and claims that "both are necessary for success in an increasingly complex and volatile business environment."[256] We follow Kotter's statement by acknowledging that leaders, in any organisational position, play a role in managing the risks that organisations are facing.

We refrain from elaborating on this distinction in this study because we believe that, with respect to the risk reduction process, both positions are considered influential at their own hierarchical level, and in their own specific capacity. We argue that non-constituted leaders, for example leaders based on seniority, professional experience, language skills, or specific specialist competences, may also play important leading roles in an organisation's efforts to control (the safety risks of) primary processes.[257] In this section we refer to people who are not formally assigned as leaders, but who may be influential to their peers or to their formal supervisors due to their personalities, and individual competences, as mentioned above. In case of a need for leadership, they will take up the leading role, and whether people will accept their roles as followers is highly dependent on the quality of leadership which emerges from collective interaction.[258] Our focus is therefore on the leader-follower relationship in general, in which leaders enable followers to follow the paths (behave) preferred by the leader.

251 Gowland (2011), p. 10.
252 Van Asselt (2000).
253 Lindhout (2019).
254 Drucker (1996), p. 1.
255 Bennis, Nanus and Garnier (2007), p. 11.
256 Kotter (1999).
257 Post (2004).
258 Ladkin (2010).

In a study into the effect of ‘knowledge sharing’, Lee presents how team roles, including the leader’s role, may shift from one to another team member where this is considered functional.[259] Depending on the specific requirements of the actual situation, people may be given or take a leading role. Hierarchy does not necessarily prevail; any member of a group (managers, as well as supervisors or their subordinate followers at the sharp end) can emerge as a leader in his or her specific individual organisational and situational context. The availability of specific relevant qualities in combination with a specific context may put relatively subordinate people into a leader’s role, which they may flawlessly fulfil.

In this respect, the work of Hook is of interest; he distinguishes two types of leaders: ‘event-making’ leaders and ‘eventful’ leaders.[260]

Event-making leaders lead an organisation proactively in issues where vision, creativity and perseverance are required to obtain innovative results. They represent the constituted leaders, acting on a strategic level.

Eventful leaders, in contrast, stand out by taking the lead in dilemmas, when everybody understands that ‘something is to be done’, but all are waiting for someone else to take the crucial decisions needed to solve the dilemma. Here it is expected that the more practical people who are operating on tactical/operational level may decide when and how to intervene upon the recognition of safety risks, in order to prevent a safety incident from occurring. Also, in cases of emergency, people may and often even will, ignore the formal organisational hierarchy and follow those who express themselves as extremely stress-resistant or skilled at leading the way to safety.[261] Ladkin also makes reference to ‘eventful leaders’ by suggesting that leadership that arises from crisis situations (e.g., fires, rescue operations, emission of toxic chemicals, medical emergencies) looks different from entrepreneurial (event-making) leadership in which someone generates a great innovative idea.[262]

Followers

Any member of a group who accepts leadership from someone acting as the leader of this group is considered to be a follower. In an organisational context this is to be understood as: ‘followers move behind a leader, following the directions and speed as indicated by that leader and by doing so, creating the change required to reach the intended common goal.’ Where leaders are successful as the commander, mediator, inspirator, or motivator, followers will execute their tasks as required to realise the intended change as indicated by the leader, regardless of his or her formal hierarchical position in (or even outside) the organisation.[263]

259 Lee, Gillespie, Mann and Wearing (2010).
260 Post (2004).
261 Cullen (1990).
262 Ladkin (2010).
263 Ibid.

Context

All operational activities are subject to the context in which they take place. This context interacts with the way people in general, including leaders, are able to cope with the physical, organisational and personal surroundings.

Different scholars suggest that the way people behave in an organisational setting, as well as the effectiveness of their actions is strongly affected by the situation surrounding them; their context.[264, 265, 266, 267, 268] The term context is to be interpreted here as physical (type of the task, working environment) as well as conceptual (organisational climate, type of the task, time of the day, ability, etc.) and socio-psychological (social relations of leaders and followers, mutual career competition, peer pressure).[269] Yukl claims that major contextual variables surrounding leaders also include the place of a leader in the organisation, characteristics of followers, the nature of the work to be executed, the type/design of the organisation and the nature of the external environment.[270]

Here organisational habits and hierarchical culture also play a role. People may resist and refuse acceptance of their role as followers of people who act as leaders. Therefore, in order to maintain the effectiveness of their acts, leaders must monitor how their followers react to their performance on a continuous basis. About this Ladkin argues: "leaders must remain within a particular 'identity orbit' in order to remain viable as 'leaders' for particular groups. If a 'leader' moves outside of the bounds of a group's identity, he is no longer able to lead."[271] Here it is assumed that leaders know how their followers look at them and that followers can only recognise themselves as 'followers' through the eyes of their 'leaders.' These perceptions are part of the context in which the people conduct their activities. If these perceptions are not positive, this creates a suboptimal context, with the potential of the leader-follower connection being impaired catastrophically.

2.3.4.2 Causal relationships in leadership processes

The figure below displays how in this process the variables: leader, follower, traits, skills, attitudes, behaviour and situational variables interact. In this diagram by Yukl[272] (Figure 17) the mutual influence of all elements on other elements meets in the nucleus node 'influence variables.' Here leaders, followers and situational context serve as key variables; a leader who demands optimal performance by his or her followers can only achieve this

264 Bushe (2011).
265 Yukl (2010).
266 Dekker (2006a).
267 Groeneweg (1992).
268 Reason (1997).
269 Ladkin (2010).
270 Yukl (2010).
271 Ladkin (2010), p. 67.
272 Yukl (2010).

by exhibiting behaviours that fit the situational context. Yukl[273] suggests that situational variables are the basis of the primary type of leadership process, in which the leader mobilises his appropriate traits and skills, in order to exhibit his most relevant behaviours, to encourage the follower to show attitudes and behaviour, which are required to realise the desired performance outcomes.

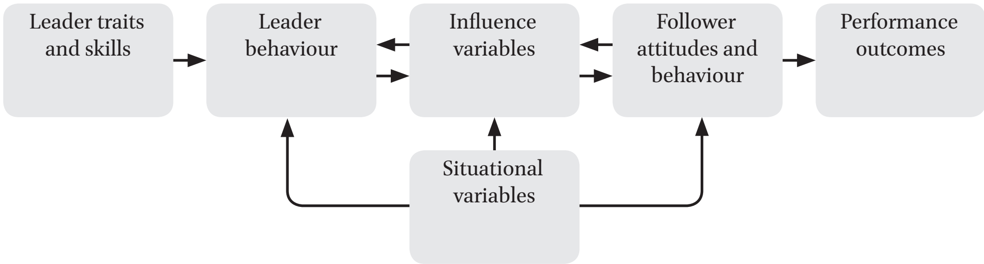


FIGURE 17 Causal relationships among the primary types of leadership processes (Yukl)

In this leadership process model, Yukl shows that leaders are not autonomous operators of their own preferred process. Their behavioural performance is restricted by their personal traits and skills. And in their attempts to achieve the desired follower behaviour, the leader depends on the specific characteristics of the situational variables (context) they are facing. For a leader, this context is only controllable to a limited degree, meaning that he or she has to be able to adapt to different, often unforeseen contextual situations. In this respect history plays a crucial role. In order to understand the actual nature of leadership applied in an operational situation, it is necessary to understand the organisational history as well as the personal histories and mutual relationships of all actors involved.

The process model as developed by Yukl represents the leadership process in general terms. In pursuance of the context of this research into the role of leaders in the prevention of safety incidents, we converted this general model by modifying the generic terminology into research-specific classifications. Therefore, we modified 'leaders' traits and skills' into 'leadership orientations', translated 'follower attitudes' and behaviour into 'risk reduction' and changed 'performance outcomes' into the outcome of the risk management process: the 'safety state of primary process.' Below, the modified, research-specific process diagram is presented (Figure 18).

273 Ibid.

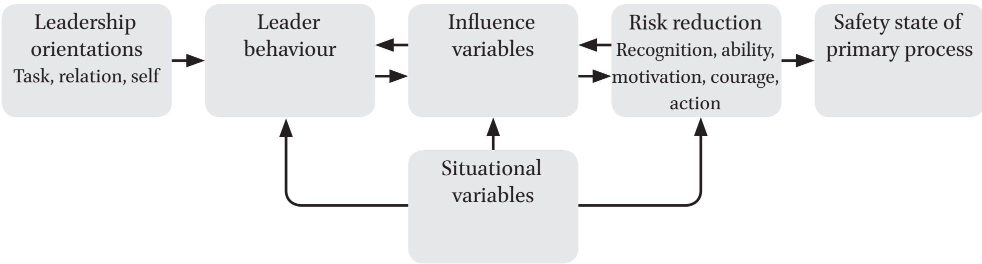


FIGURE 18 Causal relationships by leaders' influence on prevention of safety incidents

This converted version of the original process model by Yukl clarifies how leadership orientations influence leader behaviour and how risk reduction influences the prevention of safety incidents. Also, this model shows the influence of situational variables on leader behaviour, risk reduction and influence variables. Finally, the model displays the interactive relationships between influence variables and leader's behaviour, as well as influence variables with risk reduction.

2.3.5 *Behavioural motives*

In our research into what motivates leaders to behave the way they do vis-à-vis their followers, we studied the discriminating factors leading to (un)safe leadership behaviour. In order to clearly identify the discriminating factors, we considered the following leadership theories of interest: 'The Gap-Outcome-Power Model' by Leiden University, the 'Achievement Motivation Theory' by Atkinson, the 'Human Motivation Theory' by McClelland, the 'Motivational Leadership Model' by Winter and 'leadership psychopathology' by Post.

2.3.5.1 Gap-Outcome-Power Model (Leiden University)

The 'Theory of Planned Behaviour' by Ajzen[274] as described in paragraph 2.2.7.2, has been operationalised by Leiden University and labelled 'Gap-Outcome-Power' model. This model serves as one of the underpinning theories of the 'Hearts and Minds' concept as developed for Shell International Exploration and Production (Figure 19).[275] [276] This interpretation of the original model by Ajzen explicitly identifies, in addition to other parties, the role of leaders as influencers (in this model referred to as 'management') and their position in the motivating environment of actors.[277]

274 Ajzen (1991).
275 This model has been published by the Stichting Tripod Foundation in 2015.
276 Stichting Tripod Foundation (2015).
277 Van der Graaf and Hudson (2002).

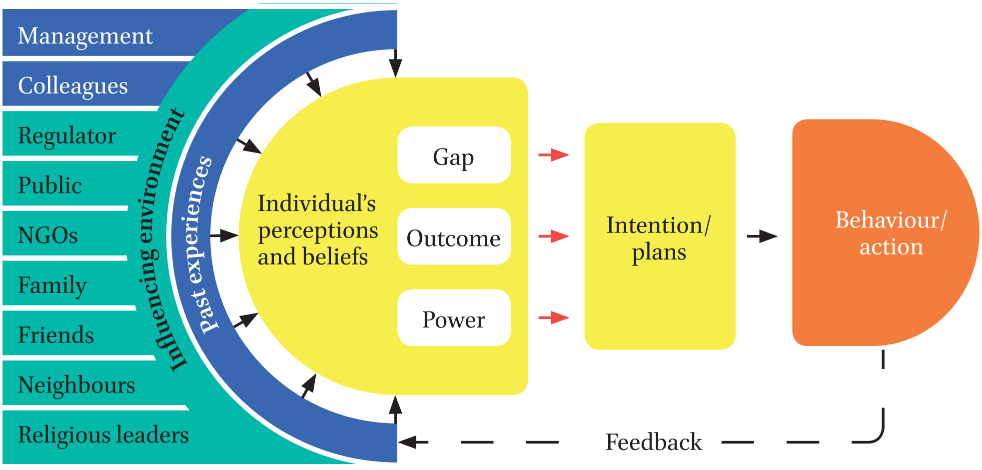


FIGURE 19 Gap-Outcome-Power Model (Leiden University)

In this model the motivating variables of an individual's perceptions and beliefs, as well as their past experiences and uncontrollable external variables created by their environment, are merged into one model. The organisational, physical and socio-psychological context in which the followers are expected to work (to execute the change process) are included. All these variables have an *influence* on the leader as well as on the follower, but not in a deterministic manner. These variables *may* alter the behavioural beliefs etc. of people, but that is not a given Newtonian logic. In this model the variables form an integrated context, which, in contrast to a deterministic 'if-then' scenario, where a variable *will determine* the outcome, result in a *probabilistic* 'if-maybe' scenario, which does not comply with predestined rules.

So, the effectiveness of this context *may* affect the actor's behavioural beliefs etc., but there is no quantitative ratio, logic, or algorithm defined, by which a calculable prediction of the influence of leaders on followers might be possible.

Followers are not in the position to modify this context. The controlling power in this context is with the leaders. It is the leader's responsibility to optimise the context of their followers. Applied to an operational setting, this theory refers, as an example, to the following possible actions by leaders: 1. Selecting and hiring the people with the 'right' attitude, 2. Convincing them of the appropriate organisation's norm with respect to risk reduction and 3. Offering them sufficient education and training facilities to enhance their skills and knowledge.

In this model, leaders are responsible for seriously considering the external variables in their strategy how to approach their followers, as these variables represent the preconditional requirements for successful operations. It also shows the dependency of followers, where it concerns performing desired behaviour. If leaders are insufficiently in control and fail to create a favourable context, followers may not perform as envisaged (Note: If-Maybe!).

Where leaders respect their roles and positions regarding the external variables, it is very likely that their followers will act as requested and their common intended purpose will be achieved. This is what we refer to as the 'leadership process of change.' Process philosophy holds that activities take place according to certain predetermined plans, or, in case of disruption of these, alternative contingency plans are activated in order to mitigate the damage.

2.3.5.2 Achievement Motivation Theory (Atkinson)

We explored which factors are indicative in order to discriminate between different typical behaviours of leaders. In our search for relevant differences in leaders' behaviours, we consider the Achievement Motivation Theory as proposed by Atkinson to be an appropriate theoretical basis. This scholar suggests that people's motivation to select a certain path of action among a set of possible alternatives is based on their specific *motive*; their expectancy that the selected path will lead to a particular *consequence* and that following this path will result in a positive *incentive*.[278] Regarding this type of motivation, this scholar identifies two problems: 1. The possible selection of the wrong path of action and 2. The resultant of the action once it is initiated and its tendency to persist for a time in a given direction. Here the individual's motivation of why to behave in a certain way is the core of the theory. So, in the context of this research, applied to leaders, we take it that this also relates to the way leaders behave vis-à-vis their followers.

In Atkinson's 'Theory of Motivational Determinants', the motivation of people to achieve certain *goals* is related to the *risks* they dare to take in order to succeed. Atkinson suggests that people's motivation to act in a certain way is based on a specific *motive*, i.e., their *expectancy* that their acts will lead to a particular consequence and that one expects that these acts will be followed by a positive *incentive*.

Atkinson takes the position that:

> A motive is conceived as a disposition to strive for a certain kind of satisfaction, as a capacity for satisfaction in the attainment of a certain class of incentives. The names given motives – such as achievement, affiliation, power – are really the names of classes of incentives which produce essentially the same kind of satisfaction: pride in accomplishment, or the sense of belonging and being warmly received by others, or the feeling of being in control and influential.[279]

In the referred article, Atkinson claims that achievement motivation may lead to behaviour towards achieving the expected goal, but also to behaviour that aims to avoid failure.

In relation to the position of leaders and their relationship to followers, in that they aim to make the followers do what they (the leaders) want them to do (or refraining from that), it requires careful preparation of the applicable success factors by first assessing

278 Atkinson (1957).
279 Ibid., p. 360.

the actual contextual situation (who are my followers and what is their contextual situation?). This may require some thoughts about the following; does the person I want to do something understand what I ask and why I ask this; is this person supportive to me (or are we 'mental enemies'); will this person accept my request; to what type of behaviour is this person extremely sensitive; what is the persons mental state at this moment; etc.? Leaders must consider these questions or situation cues before actually approaching a follower with their request. So, in order to achieve their goals, leaders assess the risks of encountering a follower's resistance, rejection of the request, or even being ignored, by which the leaders' goals are not achieved. Atkinson conducted experiments in which he tested how the differences in strength of achievement-related motivation influence behaviour in competitive achievement situations. He concluded that, regardless of the path selected by the individual, achievement of a goal or avoidance of failure, the strength of motivation is the combination of *motive* (achievement, affiliation, or power), *expectancy* (goal-attainment or failure-avoidance) and *incentive* (what's in it for me).

Since Atkinson is not specific about the limitations of application of his theory, we argue that this theory may also be applied to people's expectations in relation to the risk reduction process and with respect to this, we suggest that leaders will be most successful in risk reduction if they show behaviour which clearly takes into account their subordinates' expectations where it concerns the consequences and incentives related to compliance with their leader's requests.

2.3.5.3 Human Motivation Theory (McClelland)

Based on Atkinson's theory, McClelland developed his motivational theory.[280] McClelland's theory also addresses three typical motivational drivers: achievement (setting and accomplish challenging goals), affiliation (wanting to belong to a group, to be liked) and power (wanting to control and influence others, like to win arguments).[281] McClelland took the position that most individuals possess and exhibit a mix of these three drivers, depending on how people are influenced by and will react on their specific situational and social context. In addition to this, McClelland suggests that often one of these drivers is exhibited as the dominant one. We take the position that these drivers apply to all people, leaders as well as followers. In this paragraph we focus on leaders as the group that exhibit their behaviours vis-à-vis their followers. Regarding different influences on risk management-related cooperation by subordinates, we suggest that the influence of leaders who predominantly exhibit 'achievement'-driven behaviours, will be different from the influence of leaders who predominantly exhibit 'affiliation'- or 'power'-driven behaviours and that this applies mutually between every different motivational driver.

Based on this achievement motivation theory of Atkinson, McClelland further developed his own motivational theory. McClelland focuses on economic growth and as a

280 There are different interpretations about the sequence in which both scholars developed their theories.
281 McClelland (1987).

consequence his work is mainly based on his experiments in relation to the commercial and economic environment. His subjects are the leaders/entrepreneurs who lead their followers to achieve economic growth as main objective.

Like Atkinson, McClelland's theory involves three types of motivational drivers: achievement (setting and accomplishing challenging goals), affiliation (wants to belong to a group, to be liked) and power (wants to control and influence others, likes to win arguments).[282] McClelland took the position that people will often exhibit a mix of these three motivational drivers, depending on how they are influenced by and react to their specific situational and social context. Additionally, he suggests that often one of these drivers is exhibited as the dominant one. In the work of McClelland, 'achievement' plays a central role. Referring to the work of Darwin, he mentions the 'desire to survive' as the principal 'need', which, in his terms, is equal to the words 'motivational motive.' He differentiates between motivation and action, because people may perform similar actions for very different motives. Eating may be motivated by being hungry, but eating chocolate or ice-cream might also be a luxury satisfier.

So, McClelland focuses on motives as the expression of one's needs, regardless of the consequential following acts. Like Atkinson, he distinguishes three motive types: achievement, affiliation and power. Which motive(s) leaders use to motivate their followers depends a great deal on the specific situational context and on what the leader perceives to be the best motive to apply in relation to the individual characteristics of his particular followers.

Research results suggest that achievement-based motivation will stimulate followers when achievement in the narrow sense (e.g., high output figures) is the objective. In the sense of economic activities, achievement as defined by the leader may serve as the principal motivator for followers to undertake certain actions. But followers may have different preferences where it concerns their motivations to satisfy the request of their leaders. Where the need of people is to be liked, accepted, or forgiven, achievement motivation will be most effective.

For people who are sensitive to a personal approach or who may easily be seduced by special rewards or a pat on the back, the affiliation motive may be more effective. Here the relationship between leader and follower may be sometimes even described as 'friendship' and the 'If you scratch my back, I'll scratch yours'-effect is the leverage for success. According to McClelland, working-affiliation-based motivation indicates a close relationship between leaders and followers.

Leaders who are concerned with controlling the means of influencing people will preferably apply the power motive type.

With reference to this motive type, McClelland writes:

> Such concern may be inferred from emotional reactions to a dominance situation (e.g., pleasure in winning or anger in losing an argument, 'statements of wanting to

282 Ibid.

> avoid weakness', etc.), from dominance activities —'disputing a position, arguing something, demanding or forcing something, trying to put a point across, giving command, trying to convince someone of something, punishing someone'—or from a description of 'an interpersonal relationship which in its execution is culturally defined as one in which a superior person having control of the means of influencing the other who is subordinate (e.g., boss-worker, judge-defendant).[283]

In this quote, McClelland clearly shows his distinction between 'motive' (pleasure in…) and 'action' (disputing…).

As the work of McClelland is about economic growth and, consequently, entrepreneurship, he prominently addresses 'risk-taking' in relation to leadership. He states that "entrepreneurship involves, by definition, taking risks of some kind."[284] Having asked business executives what their core activity is, the answer was: "We make decisions."[285] According to McClelland, this is characteristic for the role of leaders, in that they are specialised in handling situations which call for something more than routine action, which implicitly involves taking risk of some kind. The emphasis on the activity of decision-making points to the specific organisational and situational context of leaders who, in their daily operation, have to deal with the significant uncertainties where it concerns successful, undisturbed operations. McClelland summarises the entrepreneurial role as: "Decision-making under uncertainty" and that is precisely what this research is about.

Did McClelland declare business people to be gamblers? Not really. McClelland stated: "The real point is that the gambler can exercise no control over the outcome, unless he uses loaded dice, whereas the businessman can influence by his actions whether his decisions will turn out in the long run to be successful or unsuccessful."[286, 287]

With reference to McClelland, we take the position that in order to prevent operational disturbances, leaders have to pay particular attention to their organisational and situational context of which individual characteristics of their followers are an important part. We suggest that leaders who predominantly exhibit 'achievement'-driven behaviours will have different influence on the effectiveness of the risk reduction process as leaders who predominantly exhibit 'affiliation'- or 'power'-driven behaviours and that this applies mutually between every different motivational driver.

2.3.5.4 Motivational Leadership model (Winter)

In a study about personalities, Winter has discovered some particularities on people's motivational preferences, or 'motive profiles.' Like the previously referred-to scholars, in this study, Winter also refers to achievement, affiliation and power motives. He con-

283 McClelland (1967), pp. 167–168.
284 Ibid. p. 210.
285 Ibid., p. 210.
286 Ibid. p. 211.
287 Disclaimer: On this we do not necessarily agree with McClelland.

cludes that personality is a complex phenomenon; motives, cognitions, traits, as well as social context (present as well as past context) play a role. Behaviours and outcome of these can be predicted, but only in contingent (if-then) ways.[288]

According to Winter, the three motives (achievement, affiliation and power) influence personality, but skills, knowledge, individual traits and social context contribute as well. Winter claims that personality can be studied reliably and objectively without direct access. To this end he developed a testing method analysing the content of the language spoken and written by leaders. This content-analysis method comprised analysis of the same three motives as used by Atkinson and McClelland (achievement, affiliation and power). Based on his analyses of the words spoken and written by his subjects, he generated their personality profiles. In his research he discovered that power-motivated people invest much of their energy in their job and they enjoy it. In contrast, achievement-motivated people are energetic too, but seem to take less pleasure in their job. Winter explains the latter with the fact that achievement-motivated people are 'living for the job' and enter their workplace with enthusiasm and idealism. But, sooner or later, setbacks like personal conflict, production pressure, or cost overrun will appear. But achievement-motivated people are quite flexible and will use feedback from other people in order to restore performance in the best possible way to continue the job as soon as possible. Achievement-motivated people function best when they are 'in the driver's seat.' Some studies suggest that people high in achievement motivation learn such control relatively early in their childhood. This may indicate a relationship between traits and motives. About that Winter claims: "Conceptually traits involve *consistency* of publicly observable behaviour [...] I believe that, while they are useful, such trait descriptions have their limits; they are certainly not a complete description of anyone's personality."[289]

Winter is not very supportive to the approach of determining someone's personality through the use of traits. To illustrate this, we refer to his finding that:

> ... among extraverts, affiliation motivation (as expected) is associated with successful interpersonal relationships; among introverts, however, these relationships significantly reverse. In other words, introverts high in affiliation motivation have affiliation-related problems. Thus, traits are not the same as motives; rather, traits channel or direct the ways in which motives are expressed in particular actions – sometimes channelling them in strange directions.[290]

Regarding personalities, in addition to traits and motives, Winter also refers to social context. There he focuses on the influences by e.g., different life experiences (e.g., a soldier in a war situation versus a clerk in an office), different roles in society (politician or business person), or different living environments (village or big town). Most notably these differ-

288 Winter (1991).
289 Winter (2005), p. 567.
290 Ibid., p. 569.

ent experiences create many differences in cognitive content and style.

Winter suggests that the concerned four domains (traits, motives, cognitions and social context) constitute the four basic elements of personality. With respect to his claim that behaviour can be predicted by knowledge of these four elements, we are somewhat reserved. Referring to specific contextual situations and scenarios, Winter claims that "in such an enterprise as studying leaders at a distance, a certain sense of humility is both necessary and becoming."[291]

On this aspect Winter suggests:

> We cannot always make absolute predictions from leaders' personalities because we cannot know future situations, especially the surprising and improbable ones that they may encounter [...] we can make contingent, conditional, 'if/then' predictions: that a person of type *X* (or a person scoring high on personality variable *X*), under condition *Y*, is likely to exhibit behaviour *Z*. We cannot know everything, but we can know something.[292]

Regarding the mentioned 'surprising and improbable situations', leaders may diverge from the 'standard' behaviour they exhibit under 'standard operational conditions', where deviations of intended processes are relatively limited and safety incidents are not an issue. In the following section, some of the latter situations and some possible related diverted behaviours are discussed.

2.3.5.5 Leadership psychophysiology (Post)

When operational processes deviate from their intended paths, operational conditions descend to a 'crisis' level and everyone feels out of control, people tend to seek surety by behaving a different way than they exhibit under normal conditions, when they perceive that they are fully in control. In conjunction with this, Yukl suggests that extreme pressure on leaders to perform a difficult task or a safety emergency situation creates a situation where "... the role expectations for the leader are likely to change in a predictable manner."[293] On this phenomenon, Post has conducted some specific research. He specifically concentrated on the way certain types of leaders react when facing stressful, possibly crisis situations. With his approach he took a different, psychophysiological route to explain how and why leaders behave different when they encounter an unexpected stressful situation, one which means 'emergency!' to them.[294]

Time constraints, (perceived) urgency, ambiguity, uncertainty, uniqueness and surprise can be mentioned as contributing factors to the mental stress being generated in

291 Winter (1991), p. 579.
292 Winter (2005), p. 579.
293 Yukl (2010), p. 92.
294 Post (2004).

people who face a safety incident.

According to Post, the character of decisions made under critical conditions, e.g., during a safety incident, differs from that of the day-to-day rational routine process of decision-making under normal operational conditions. In his research, Post focused on the quality of behaviour by politicians in crises. He concludes that "the consideration of the individual is, for the most part, undifferentiated."[295] We have no reason to assume that decision-making under crisis conditions by leaders in an organisational setting is of a different nature. In this respect we also refer to the Thomas' theorem: "If people define situations as real, they are real in their consequences."[296] In his explanation of understanding behaviour under crisis conditions, Post differentiated between the roles of people and their individual personality. Post claimed that there is no one-to-one relationship between the significance of an incident (as defined above) and the amount of stress (as experienced by an individual). What threatens someone, resulting in psychological stress, may differ substantially from what threatens someone else. But the particularities of an incident are independent of individual experience.

Under stress, characteristic defence patterns intensify, thus different personality types may react differently to identical external stress-generating signals. Of special interest are the defence patterns of 'avoidance' and 'hypervigilance.' Avoidance is the result of not defining the situation as an incident or delaying taking a decision due to the inability to cope with the situation at hand. In contrast, hypervigilance is the situation where someone feels the urgency 'to do something', resulting in quick decision-taking before the situation is properly assessed.

The literature in the safety domain does not answer the question of which leaders are particularly apt to behave in a certain way – or 'why people react the way they do under particular circumstances.' But what is known, is that ambiguity seriously influences the tolerance of individuals and that this is related to personality and consequent orientation.

Research by Post has discovered that successful, but compulsive, individuals are characteristically uncomfortable with uncertainty. In ambiguous situations, they behave very differently than action-oriented people, who react more intuitively. The latter are not stressed as easily as their compulsive colleagues may be. Although an action-oriented individual may step more easily into the pitfall of hypervigilance, he or she feels uneasy when nothing is done and does not feel comfortable until 'something is done.' Under escalating conditions, it is of extreme importance to accurately assess the point at which one considers the situation to be of critical proportions and when this situation is irreversibly heading into a major incident. Here also the personality disposition of the leader plays a crucial role, as both errors in calling a non-crisis an incident as well as underestimating the criticality of an actual crisis situation may have major consequences.

A different risk where one may encounter the above-mentioned errors in decision-making, is where the problem may appear due to flawed functioning of the leader's

295 Ibid., p. 102.
296 Merton (1995), p. 380.

cognitive faculties, caused by a medical situation, e.g., due to organic brain damage. In such a case the leader's capacity to assess an escalating situation may be reduced to a level where replacing that leader becomes a, possibly uneasy, but necessary, consideration in order to prevent escalation of a threat into an incident situation.[297]

Regarding leaders in (perceived) crisis situations, Post distinguishes three personality types: compulsive, narcissistic and paranoid leaders. He argues that compulsive and narcissistic leaders are quite common. Paranoid leaders are much less apparent, but he includes this personality, because "aberrant reactions of paranoid individuals under stress can have catastrophic consequences."[298] Where individuals have compulsive, paranoid, or narcissistic personalities (as many successful leaders do), these traits can be expected to grow to extreme proportions under stress conditions.

In the following paragraph we will elaborate on the core properties of the referred personalities as presented by Post.

The compulsive personality[299]

This personality type is often found among successful leaders in executive and managerial positions, who are used to being the ones to whom people look when important decisions are to be taken. The properties that often contribute to the success of people who are identified as compulsive are: good organising capabilities, attention to detail and emphasis on rational processes. Thinking is dominant over feeling and there is a need to keep strong feelings like anxiety and anger under control. Compulsive personalities take decisions on a rational basis and try to assess and eliminate all possible risks before deriving a conclusive decision.

However, under stress conditions or, even more, in crisis situations, often there is no time to consider all possible solutions to mitigate the hazard. Then the compulsive leader, under time pressure and understanding that he is the designated person who should decide which course to take in order to resolve the situation, may mistakenly appraise the situation, resulting in a quick, but failing, remedial action. In contrast, in order to prevent quick, but wrong, decisions, compulsive leaders may become disabled and preoccupy themselves with detail; no longer overseeing the situation, they then become paralysed, resulting in indecisiveness.

Compulsive leaders, when under pressure, isolate themselves from followers in order to give themselves to think and come up with the right solution. At that time, no well-intended, or possibly useful, support from anyone is welcomed; the leader him/herself 'will lead his/her people to safety.' In general, compulsive leaders are compliant and pay respect to formal procedures. Therefore, a way of reducing the risks of the described behaviour is to prepare formal emergency procedures that will offer guidance on how to resolve different types of safety incidents. Most likely, compulsive leaders will follow

297 Post (2004).
298 Ibid., p. 106.
299 Ibid.

pre-defined recommended courses of action, because these give them the security of complying with what is expected from them. But if they are under stress and choose to refuse advice from anyone, these individuals may easily misjudge the symptoms of the accident scenario they are in. Then, unknowingly, they may trust a procedure, which does not match the actual crisis situation at hand.

The paranoid personality[300]

The core properties of paranoid personalities are: pervasive and long-standing suspicion and mistrust of people in general. Paranoids are always expecting plots and betrayal and see enemies all over the place. In part this is caused by an embellished need for autonomy; they trust nobody except themselves. Suspiciousness is the paranoid's basic theme in life. They will always seek confirmation of their own assumptions, attitudes and biases. And they are always looking for clues that confirm their own conclusions. Paranoids tend to be rigid and unwilling to compromise. When they are convinced of the existence of a certain hazard, no contradictory evidence will change their minds; what they 'see' is real. In such case, real paranoids may become hostile, defensive and stubborn and no reasonable argument will suffice to convince them of their mental flaws. In stress situations, paranoids can become dysfunctional and should be taken out of their leading position (where, in fact, they never should have been assigned to anyway). The greater the stress, the more paranoids hold to their fantasy impression of the world. Where, due to their hierarchical power positions, paranoids are considered to be influential in crisis situations, compensating measures are to be taken to prevent paranoids' actions from endangering the organisation and/or its environment.

The narcissistic personality[301]

In principle, a narcissist is a person with extreme self-confidence. These leaders can be very successful, as a mix of self-confidence and ability is a successful combination of traits. But extreme, full-blown narcissism can be inconsistent with sustained effective leadership. Leaders with a strong narcissistic personality surround themselves with followers who agree with everything they say and do whatever they want them to do. These followers are selective with respect to information to their leader, especially where they consider that this information might not be welcomed. For narcissists, their self-esteem maintenance function dominates and criticism on their actions is not accepted and may result in disciplinary consequences. A narcissist may design his/her own reality and be living completely out of the 'real world.'

Post elucidated a narcissistic person as "so vulnerable under his grandiose façade, that it is difficult for him to acknowledge ignorance and, accordingly, to accept information or constructive criticism of his ideas."[302] As these leaders are overly confident about

300 Ibid.
301 Ibid.
302 Ibid. p. 109.

the greatness of their ideas, they overestimate the probability of success for their plans. If they are in the position to take crisis-related decisions, they can be a real danger to their environment. Where there is no option to avoid narcissistic leaders as counterparts in an incident situation, one should take caution and consider to follow the advice by former US President Ronald Reagan: "Trust, but verify."[303]

Conclusively on these three personality types Post stated: "It emphasizes the point that in considering the effects of personality on crisis reactions, one must consider the interaction between different personalities in the decision-making hierarchy [...] The decision maker does not make decisions in splendid isolation but in relation to a chain of command. The interplay of personalities can influence both the information on which the decision maker acts and the manner in which his decisions are implemented."[304] This statement by Post may serve as a clear directive for the functionaries who are responsible for the design of organisations and the consequential selection and hiring of employees (this applies for leaders as well as followers).

2.3.6 *Profiling leaders*

The leadership theories as referred to in the previous sections are different in the descriptions of the discussed motivational drives. In order to deliver an unambiguous and normalised representation of these different drives, we will concur with the terminology as defined in Section 4.2.3 'Leadership characteristics'. Where applicable, we will therefore use the following terms: 'Leadership orientations', 'Task-oriented leaders', 'Relation-oriented leaders' and/or 'Self-oriented leaders.'

We elaborate on these characteristics in order to profile leaders. For each leadership characteristic, we explain: a) the leader's particular orientation, b) the leader's relevant motivational drive, and c) the specific indicators considered relevant for the particular leadership characteristic.

Below, a comparison table (Table 1) shows how the different motivational drives as mentioned by Atkinson, McClelland, Winter and Post, as previously discussed in this section, compare with these three leadership orientations.

303 Reagan (1987), p. 110.
304 Post (2004) p. 113.

Orientations	Atkinson	McClelland	Winter	Post
Task	Achievement	Achievement	Achievement	Compulsive
Relation	Affiliation	Affiliation	Affiliation	Paranoid
Self	Power	Power	Power	Narcissist

TABLE 1 Comparison of leadership characteristics versus motivational drives

The (identical) terminology as used by Atkinson, McClelland and Winter, applies to an organisational state of 'normal operations.' The terminology used by Post refers to situations where leaders are under high mental pressure or the operations are in a state of facing a (potential) major incident. These tense situations may seriously affect the way leaders behave.

Pardey explains that disorder and uncertainty are stressful and he argues:

> Crises mean that the normal order and certainty of the workplace have been disrupted and people feel that they have lost control of their own world. The result of this is anxiety which can become panic if the incident is particularly severe and/or sudden in its impact. This is when people start to behave like headless chickens – they cannot see what they should be doing or do not seem able to make sensible decisions. They have the tendency to assume that, since normality has disappeared, the normal rules no longer apply and lose any sense of direction, heading off in different directions because they do not know which way they should be heading."[305]

Also, Pardey[306] suggests that in stressful situations, when there is time pressure and limited information, leaders may change their approach and e.g., refuse to consult other people.

Post[307] elaborates on this phenomenon and distinguishes different reactions where it concerns the different leadership orientations. He argues that there are three possible behavioural reactions (see also 2.3.5.5): compulsive, paranoid, or narcissist. Based on the nature of the three different leadership orientations, we argue that, when experiencing an incident situation, Task-oriented leaders may change their behaviour as exhibited under normal operational conditions into compulsive behaviour, Relation-oriented leaders may alter their normal behaviour into a paranoid variant of behaviour and Self-oriented leaders may show the tendency to exhibit narcissistic behaviour. In the section referring to Post, we quoted his statement: "The decision maker does not make decisions in splendid isolation but in relation to a chain of command."[308] In this context Post specifically

305 Pardey (2007), p. 177.
306 Ibid.
307 Post (2004).
308 Ibid., p. 113.

mentions the influence of interaction between leader and followers under conditions of mental stress.

Stogdill claims that: "A person does not become a leader by virtue of the possession of some combination of traits … the pattern of personal characteristics of the leader must bear some relevant relationship to the characteristics, activities and goals of the followers. Thus, leadership must be conceived of in terms of the interaction of variables which are in constant flux and change."[309] In that respect, Winter proposes that personality is built from four basic elements: personal traits, motives, cognitions and cognitive constructions and social context.[310] Based on these four elements, people choose, consciously and unconsciously, what elements of which orientations they will adopt in which context. So, the behaviours exhibited by leaders are instigated by more properties than 'leadership orientations' alone. In an intervention experiment aimed at improving supervisors' effectiveness with respect to operational safety, Zohar[311] argues that improved transactional supervision enhances safety behaviour of operational employees and that transformational qualities result in incremental effects.

Horner also refers to the relativity of profiling people. He suggests that people's behaviours are dependent and therefore contingent on interaction of the leader's traits, the leaders' behaviours and the specific context of the leader. Horner supports the idea that leaders may decide to apply different leadership orientations in different situations.[312] Therefore, according to Horner, leaders' behavioural patterns are not static individual attributes, but may be applied 'as appropriate', depending on the specific organisational and situational context. But this does not imply that it is not useful to identify the predominant behavioural patterns as exhibited by leaders.

The above considerations have led to the assumption that the three leadership characteristics (Task, Relation and Self orientations) are useful distinctions for characterising the influence of leaders on the prevention of safety incidents. In the following paragraphs, leadership profiles for Task-, Relation- and Self-oriented leaders are described. Each of these descriptions include the leaders' focus, motivational drives, leadership roles and behaviour indicators.

2.3.6.1 Task-oriented leaders

Yukl[313] suggests that leaders who are Task-oriented perform their leading responsibilities primarily with a focus on activities which facilitate completion of the work in an effective and efficient way, like the coordination and facilitation of the primary processes. The Task-oriented leader is the key person for ensuring that the tasks required to achieve the organisation's objectives are performed. A Task-oriented leader concentrates on func-

309 Stogdill (1948), p. 64.
310 Winter (2005).
311 Zohar and Luria (2003).
312 Horner (1997).
313 Yukl (2010).

tions like planning, scheduling, coordinating activities and ensuring that the required supplies and equipment are provided and they render assistance where required. During routine operations, Task-oriented leaders set high, but realistic, targets. These leaders are to be considered as 'achievement-motivated' leaders.

According to Atkinson, for achievement-motivated people, the following applies: "… the attractiveness of success is a positive function of the difficulty of the task…."[314] During interaction with their followers, Task-oriented leaders primarily choose to play the roles of motivator and achiever and act as a knowledge base for their followers. Task-oriented leaders are focused on achieving satisfaction in job performance and are therefore likely to promote future task performance of their team. For instance, research by McClelland[315] shows that Task-oriented leaders are evaluated in terms of standards of excellence where intelligence and leadership capacity are concerned. In order to strive for optimal results in (non-routine) job performance, Task-oriented leaders apply their knowledge to support their team members in improving task performance.[316] Also for Task-oriented leaders, job-related knowledge and skills, if applied to helping subordinates to better perform their tasks, are a major source of personal power.[317]

Pardey claims that leadership is "… the ability to bring about movement or change in a group or organisation, when there is risk or uncertainty, by inspiring others to head in a particular direction."[318] But the world around leaders is not a static given; for instance, as Ladkin explains, the world is actually in a state of flux, changing all the time, as well as generating its innovations at a fast pace.[319] So, the Task-oriented leader is not only charged with the task to *bring about* change, he or she must also be prepared to *cope with* external changes (e.g., different requirements about products by clients, increased legislation, environmental requirements from the surrounding society, different technologies) the organisation may be facing.

In that respect, McClelland[320] takes the point of view that the Task-oriented leader's mission to optimise results implies continuously seeking more efficient and effective innovative means and methods. This means that a Task-oriented leader would not properly exercise his/her leading role by ignoring the intellectual capacity and skills of the team members. So, according to Pardey,[321] in the leader's attempts to achieve optimal results and to get commitment from followers about a plan of action, the Task-oriented leader shares his/her challenges with the followers and is truthfully interested in their ideas. As argued by McClelland, in order to prevent the occurrence of such uncontrollable situations, Task-oriented leaders put effort into assessing the risks that apply to the operations

314 Atkinson (1957), p. 362.
315 McClelland (1967).
316 Ibid.
317 Yukl (2010).
318 Pardey (2007), p. 15.
319 Ladkin (2010).
320 McClelland (1967).
321 Pardey (2007).

they lead. McClelland claims: "a great part of the efforts of business executives is directed at minimizing uncertainty."[322] McClelland[323] claims that, especially when in an entrepreneurial role, where Task-oriented leaders are relatively autonomous, they believe in taking 'moderate' risk as a function of skill not chance, and then decide about the (non-) acceptance of this in relation to the drive to achieve the organisational objectives.

As explained by Yukl,[324] in leading operations, Task-oriented leaders have one primary objective: meeting operational targets. Therefore, any unanticipated operational interruption means a critical and often uncontrollable disturbance of the leader's plans.

However, Atkinson[325] suggests that in addition to the motive to maximise performance, Task-oriented leaders also aim at operating as efficiently as possible, which implies taking risks for failure.

McClelland[326] questions whether Task-oriented leaders are really able to judge the risks they take by their decisions to consider these as acceptable. Regarding this, he refers to the work of Sutton,[327] who claims that: "… there is a strong tendency among businessmen to emphasize that their decisions are based on 'facts' and thus to make favourable outcomes the consequences of perspicacity and 'judgement' rather than good fortune…."

The people running the primary operational processes, the leader's team, know their daily processes and they have their personal perception about the accompanying risks for unanticipated incidents. These people are physically in the best position to recognise and understand these risks. Through their operational knowledge and skills, they are also the people who know how to prevent these risks from escalating into incidents, resulting in personal injury, asset damage, or loss of organisational reputation.

For that reason, a Task-oriented leader typically respects the risk assessment of the team and, as referred to by Van Kampen et al.,[328] motivates them to intervene when they identify risks, which they consider to have the potential to create unanticipated process disruptions.[329] The Task-oriented leader will then balance the risks and the primary operational targets and take a decision on which path to follow. In some cases, e.g., where there is no agreement between the different actors involved, such decision may be based on the leader's intuition.[330, 331, 332]

In order to achieve his/her goals, a Task-oriented leader must sometimes be flexible

322 McClelland (1967), pp. 210.
323 Ibid., pp. 207–214.
324 Yukl (2010).
325 Atkinson (1957).
326 McClelland (1967).
327 Sutton (1954), p. 23.
328 Van Kampen, Van der Beek, Steijn, Groeneweg and Guldenmund (2017).
329 Bennis (1989).
330 In the context of this research, we consider the following definition by Michie (in Van den Herik, 2016) most applicable: "Intuition is simply a name for rule-based behaviour where the rules are not accessible for consciousness."
331 Van den Herik (2016).
332 Sutton (1954).

concerning compliance with procedures or protocols; however, that is inherent to the position and the nature of Task-oriented leaders and their moderate risk appetite: "Making decisions." [333, 334, 335] In this respect, Bennis takes the point of view that: "Your (read: the leader's) jobs charter must allow you to take risks, make mistakes, use your creativity to the hilt and encourage those who work with you to do the same."[336]

But the above-mentioned individual considerations, assessment of risk and consequential decisions by the Task-oriented leader are not only economically driven. The leader's obligations also include legal accountabilities, as well as a moral responsibility for the safety and well-being of the team.[337, 338, 339, 340, 341, 342, 343] Implicitly Task-oriented leaders carry the responsibility of identifying and assessing risks that might threaten their people and, where these risks are not shown to be within acceptable limits, ensuring improvements, especially where it concerns the quality "… to which changes (i.e., to working methods, organisational structure or staffing resources) are carried out, by taking into consideration any potential consequences…".[344]

Summarising, quoting McClelland: "Task-oriented leaders will choose an expert over a friend."[345]

The job-related properties of Task-oriented leaders as described above, are specifically valid during 'normal operations.' The tasks and responsibilities described above may be considered as natural parts of their preferred way of achieving an organisation's objectives. However, Post (ref. 2.3.5.5) argues that, when Task-oriented leaders face serious critical conditions and experience high levels of mental stress during the fulfilment of their tasks, they may modify their normal Task-oriented operational mode and escape into a compulsive type of behaviour.[346] The leader then moves away from an interactive communication style, to a strict and directive communication style.

333 Dekker (2016), p. 59.
334 McClelland (1967), p. 210.
335 Yukl (2010), p. 22.
336 Bennis (1989), p. 2.
337 Arbeidsomstandighedenwet (2004).
338 BRZO (1999).
339 Wet klachten en geschillen in de zorg (2016).
340 Mijnbouwwet (2003).
341 Spoorwegwet (2005).
342 Pardey (2007).
343 Gabriel (2015).
344 Van Kampen, Van der Beek, Steijn, Groeneweg and Guldenmund (2017), p. 212.
345 McClelland (1967), p. 232.
346 Post (2004).

2.3.6.2 Relation-oriented leaders

Pardey suggests that Relation-oriented leaders "… empathize with others, identify with their feelings and are concerned how their actions affect others."[347]

In research by McClelland, Relation-oriented leaders are considered to be 'affiliation-motivated.' In an explanation, this theorist describes affiliation-motivated people as "… people who are concerned over establishing, maintaining, or restoring a positive affective relationship with another person. This relationship is most adequately described by the word 'friendship.'"[348] But according to McClelland, these friendly leaders "… tend to have subordinates who feel that they have little responsibility, believe that organisational procedures are not clear and have little pride in their work group."[349] Based on this connotation, one might expect that Relation-oriented people, because they like "… warm, close relationships with other people …",[350] are less interested in economic results. Although this was not anticipated by the researchers, the results of research by McClelland et al., show that Relation-oriented people proved to have an unexpected positive effect on measures of economic development indeed.[351] According to McClelland,[352] contrary to Task-oriented leaders, Relation-oriented leaders dislike uncertainty and are risk averse; Relation-oriented leaders 'prefer to walk on the safe side.' This risk-avoiding behaviour of Relation-oriented leaders is also shown by reluctance to take necessary, but unpopular decisions. But leaders who primarily want to be liked and always want to stay on good terms with everybody may easily be tempted to making exceptions for the particular needs of individuals. As McClelland claims, then "… the whole system will break down."[353] According to McClelland, this kind of behaviour may confuse team members and create uncertainty about the mutual relationships between the leader and team members. This may especially affect the level of trust by followers vis-à-vis their leader, which is fatal for mutual relations. Relation-oriented leaders favour collaboration over competition and, quoting McClelland: "Relation-oriented leaders will choose a friend over an expert."[354]

This coincides with results from other research (known as the 'Michigan' and 'Ohio State' leadership studies) and suggestions by Yukl that trust and confidence, acting friendly and considerate, trying to understand the problems of subordinates, supporting subordinates in their professional development, keeping them informed, appreciating their ideas, allowing them a sufficient level of autonomy and showing recognition for subordinates' contributions and accomplishments were mentioned as supporting behav-

347 Pardey (2007), p. 56.
348 McClelland (1967), p. 160.
349 McClelland and Burnham (1976), p. 20.
350 McClelland (1967), p. 161.
351 Ibid.
352 Ibid.
353 McClelland and Burnham (1976), p. 15.
354 McClelland (1967), p. 232.

iour that were correlated with *effective* leadership.[355] According to Yukl,[356] Relation-oriented leaders focus on good social interactions; their predominant approach to their followers is 'supportive and helpful.' Yukl summarises the core duties of Relation-oriented leaders as follows: "Supporting, developing and recognizing are key Relation-oriented behaviours."[357] Also, Yukl argues that the other side of the coin is that Relation-oriented leaders tend to show favouritism to team members who are known as being their personal friends.[358] With reference to this, Yukl argues that it is not desirable for a leader to have a very strong Relation orientation, but the reverse is also true. A leader who is weakly Relation-oriented may be too introverted and shy to make the necessary connections with his/her followers and other parties with which a leader is required to communicate to ensure a successful operational result. Regarding this, Yukl[359] concludes that the optimal Relation orientation is 'moderately weak', rather than either strong or very weak.

In line with the latter, Likert proposed that: "… a manager should treat each subordinate in a supportive way that will build and maintain the person's sense of personal worth and importance."[360] Summarising different research results, Yukl argues that: "… increases in Relation-oriented leadership behaviour usually resulted in higher subordinate satisfaction and productivity."[361]

In addition to this discussion about the strength of the orientation, Bennis[362] and Pardey[363] mention three important, different properties which should be carefully managed: honesty, personal integrity and fairness. These apply especially to Relation-oriented leaders, because these leaders base their success or failure a great deal on their social skills; when these three properties are lacking, the leader and the team are in deep trouble. Pardey and Bryden both suggest that the reason why these properties are so important is because these properties underpin an important element of Relation-oriented leadership: *trust*.[364, 365]

Bennis[366] claims that trust is manageable and its main determinant is 'constancy'; people want to know where their leaders stand and what they stand for.

Within the context of this research, the requirement of mutual trust between leaders and followers touches on a specific topic: leaders rendering trust to general employees to be authorised to act without consultation if deemed necessary for safety reasons. In ad-

355 Yukl (2010).
356 Ibid.
357 Ibid., p. 130.
358 Ibid., p. 60.
359 Ibid.
360 Ibid., p. 107.
361 Ibid., p. 111.
362 Bennis (1989).
363 Pardey (2007).
364 Ibid.
365 Bryden, Flin, Hudson, Vuijk and Van Der Graaf (2006).
366 Bennis (1989).

dition to the perspectives of, for instance, Hopkins,[367] Pardey,[368] and Leistikow,[369] safety legislation[370] is clear about the fact that leaders are criminally liable in cases where safety incidents occur. However, as Weick[371] argues, our perception of possible scenarios of risk before an incident has materialised, is constrained by the limitations of our imagination, which is substantially steered by individual experience and memory.

Moreover, Ale[372] argues that risk acceptability is a complex issue and, in principle, a political one. Therefore, leaders who trust their team members, share their responsibility for incident prevention with their followers and delegate the authority to intervene, run certain accountability-related legal risks. Thus by sharing this responsibility, Relation-oriented leaders show personal courage and face the following two challenges: 1. These leaders dare to take the risk of being criticised by their superiors (and third parties) in case an operator's decision to interrupt the primary operational process is, afterwards, considered unjustifiable; and 2. Although their responsibilities and accountability are not reduced, these leaders dare to rely on their subordinates, who are hierarchically on a lower level, but who, by their leader, are considered experts in their trade. Due to their predominantly socially angled behaviour, Relation-oriented leaders are considered to be able to cope with exposure to these challenges.

With respect to this, reference is made to the concept of High Reliable Organizing (HRO). In HRO, mutual trust and cooperation of different disciplines and organisational levels are considered basic requirements for the reliability of operations. One of the basic principles of HRO is "sensitivity to operations."[373]

Hopkins extends this by arguing that members of organisations should be: "sensitive to the experience of frontline operators, encouraging them to speak up."[374] In this principle, the leader's trust is embedded in the quality and integrity of operational workers. In organisations facing safety-critical processes, disruptions of the primary process sometimes do not allow for time-consuming consultations. In critical situations, where an unexpected trigger initiates a safety incident in an acute manner, operators' attention to safety should not be limited to 'speaking up': in those cases, they must act and sometimes interruption of the primary operational process is the only option to prevent a safety incident to occur. With respect to those situations, 'intervene' is a better description of the operators' duty than 'speaking up.'

Taking into consideration how Relation-oriented leaders are described here, we suggest that Relation-oriented leaders can also be considered as leaders who empower their followers to take autonomous courageous decisions, including, if considered required by

367 Hopkins (2008).
368 Pardey (2007).
369 Leistikow (2010).
370 Arbeidsomstandighedenwet (2004).
371 Weick (2005).
372 Ale (2009).
373 Weick and Sutcliffe (2007), pp. 12–14.
374 Hopkins (2008), p. 113.

these followers, shutting down the primary operational process. Relation-oriented leaders are responsible for (the consequences of) all decisions taken by their team members and, when required, they should defend them to anyone and in every place. Relation-oriented leaders will do so. It is this moral standing of Relation-oriented leaders, along with their social interest, that sets these leaders apart from other people.

As Gabriel suggests: "Followers expect leaders to be competent just as they expect professionals and others; but they also expect leaders to provide moral leadership."[375]

The above description of Relation-oriented leaders applies specifically to their behaviours as exhibited during 'normal operations.' The way predominantly social people deal with operational tasks, responsibilities and followers, may be considered as their preferred way of achieving the organisation's objectives with respect for their team members as prime priority.

However, according to Post (ref. 2.3.5.5),[376] when Relation-oriented leaders face serious critical conditions and experience high mental stress during the fulfilment of their tasks, they may modify their social, Relation-oriented operational mode and escape into a paranoid type of behaviour.

2.3.6.3 Self-oriented leaders

As argued by McClelland,[377] Self-oriented leaders (by this theorist referred to as 'power-motivated') are concerned with the control of the means of influencing other persons. Dominance over situations (e.g., pleasure in winning or anger in losing an argument, statements of wanting to avoid weakness) or activities (e.g., disputing a position, arguing something, demanding or forcing something, giving a command, trying to convince someone of something, punishing someone) plays a central role in the practice of Self-oriented leaders. Research as referred to by McClelland shows that Self-oriented (power-motivated) leaders are not significantly related to economic development. But without power, there is no movement and since the primary objective of a leader is 'to attain change', some power needs to be applied in all cases. McClelland refers to 'the socialized face of power' and argues that the application of power "… must be disciplined and controlled so that it is directed toward the benefit of the institution as a whole and not toward the manager's personal aggrandizement."[378] In his research data, McClelland found ample evidence that individuals who show no sign of inhibition or self-control exercise their power impulsively and are often rude to other people and the like. This is the type of leader who is considered a threat where it concerns the responsible operation of the primary processes of an organisation. To identify the contrasting views of power-motivated (Self-oriented) and affiliation-motivated (Relation-oriented) people, Mc-

375 Gabriel (2015), p. 316.
376 Post (2004).
377 McClelland (1967).
378 McClelland and Burnham (1976), p. 4.

Clelland uses the terms "ego" and "alter."[379] These words clearly emphasise the opposite characteristics of Self-oriented and Relation-oriented people. According to McClelland and Burnham, the more effective leaders show more Self- than Relation orientation and they take the position that "… the bogeyman of authoritarianism has been wrongly used to downplay the importance of power in management."[380] In an explanation, McClelland claims that a Self-oriented leader, because he delivers clarity to the team about what is required and what he want his followers to do, creates a better morale in subordinates than the 'friendly', Relation-oriented leader, who is vaguer in this respect; Self-oriented leaders apply clear rules universally. But this does not imply approval for dictatorial behaviour directed to aggrandisement of the leader him/herself.[381]

According to Winter: "Successful leaders and managers must use power – to influence others, to monitor results and to sanction performance; but this power must be exercised in 'responsible' ways that involve ethical standards, accountability for consequences and a concern for effects on subordinates and peers."[382]

Pardey[383] suggests that Self-oriented leaders focus on their individual feelings, have a sense of autonomy and concentrate on their own needs. And according to a taxonomy developed by French and Raven,[384] the type of power predominantly used by Self-oriented leaders is referred to as 'coercive power.'

Yukl[385] puts this in perspective of the general role of leaders: to create change, one needs the application of power. However, as Yukl claims, there are different types and degrees of power and which type a leader applies to what degree depends on a complex set of factors, e.g., the context in which leadership is being exercised, the personal traits of leader and follower(s), the relationship between the parties and the specific activity at hand. Yukl[386] claims that leaders' coercive power is based on authority over punishments, which varies greatly across different types of organisations. Compared to two centuries ago, the use of coercive power has declined, but there are still sectors (e.g., the military, mining, aviation, marine, industrial operations, etc.) where discipline is considered as an important aspect for achieving operational goals in a safe and responsible way.[387] About these traditional/formal situations, Yukl argues that: "Coercive power is invoked by a threat or warning that the target person will suffer undesirable consequences for non-compliance with a request, rule, or policy."[388] With reference to the degree of coercive power, Yukl suggests that the lateral relationship (read: hierarchical distance)

379 McClelland (1967), p. 171.
380 McClelland and Burnham (1976), p. 24.
381 Ibid.
382 Winter (1991), p. 77.
383 Pardey (2007).
384 French John Jr and Raven (1959).
385 Yukl (2010).
386 Ibid.
387 Probably there is a relationship between the type of operation and the associated relative high safety risks.
388 Yukl (2010), p. 206.

between leader and follower might be of influence; where followers are dependent on their leaders for career development, more power is accepted as, for instance between two leaders, working in different departments and being mutually dependent.

Traditionally, organisations are built as abstract hierarchical constructions, with the most empowered person, the 'boss', at the top of the pyramid. Depending on their hierarchical positions, leaders are granted more or less hierarchical power over more or less followers and the level on the pyramid determines the extent of authority of leaders over their followers. In exercising their authority, leaders use their preferred type and degree of individual power and Self-oriented leaders typically prefer to apply a strong degree of power.

Nevicka et al.[389] argue that: "… the insatiable need for glory might lead narcissistic leaders to pursue unrealistic projects and risky investments, or even display unethical and counterproductive work behaviour …" and that "… narcissistic CEOs were found to make riskier decisions that result in greater volatility in organisational results …." They also claim that narcissistic leaders, in addition to having negative characteristics like overly positive self-views and perceptions of superiority over others, may initially show positive behaviours, such as charm, confidence, humour and extraversion but these initial positive impressions do not seem to endure. Power distance and personal contact between narcissistic leaders and their followers seem to be influential factors. Only followers who had relatively fewer opportunities to observe their leaders perceived those leaders as being more effective. These observations were absent in followers who had better opportunities to observe their leaders. According to Nevicka et al., professionalism and organisational experience is also important for a leader's functioning.

Focusing on the effect of Self orientation on the relationship between leaders and followers, Ladkin[390] proposes that leaders must remain in their particular 'identity orbit' in order to remain viable as leaders for particular groups. If leaders act in a too Self-oriented manner, do not respect the link between their point of view and that of their followers, they run the risk of moving too far away from their 'identity orbit' and might lose the required authority to function as leader. This scholar refers to this effect as 'lack of reversibility', using the following words: "'Reversibility' suggests that 'leaders' know who they are through the eyes of their 'followers' and, likewise, 'followers' can only know themselves as 'followers' through the eyes of their 'leaders.' When these perceptions jar against deeply held ego identities, the leader-follower connection can be severed."[391] Where Self-oriented leaders do not care for their followers' 'identity orbit'; they walk in their own direction and often too far away and therefore trust will evaporate and they lose grip on the people they are supposed to lead.

In conclusion, it should be clear that the above descriptions of Self-oriented leaders apply specifically to their behaviours as exhibited during 'normal operations', and these

389 Nevicka, Van Vianen, De Hoogh and Voorn (2018), pp. 703–723.
390 Ladkin (2010), p. 67.
391 Ibid., p. 67.

leaders predominantly deal with their operational tasks, responsibilities and followers.

For Self-oriented leaders, this is the preferred way of achieving the organisation's objectives. And to reach their goal, they apply the type and amount of power they feel is required. But power has to be applied in a controlled way and being in the powerful position also holds the risk that these Self-oriented leaders exhibit too little inhibition. In such cases, the hierarchical authority of a Self-oriented leader could inadvertently lead to behaviour with a priority for achieving their personal objectives. In relation to this, Post[392] argues that, when Self-oriented leaders are facing serious critical conditions and experience high mental stress during the fulfilment of their tasks, they may lose their controlled Self-oriented operational behaviour and escape into a form of narcissistic leadership.

Rosenthal and Pittinsky[393] argue that the psychological underpinnings of narcissistic leaders might include arrogance, feelings of inferiority, an insatiable need for recognition and superiority, hypersensitivity and anger, lack of empathy, amorality, irrationality and inflexibility and paranoia. In serious critical conditions, these behavioural properties will not be helpful to prevent escalation.

2.3.7 *Summary*

In these sections, we elaborated on the concept of leadership. We proposed to consider leadership as a social construct and expanded on the leadership process, in which we discussed leadership behaviours and how the different leadership variables may interact. The descriptions of the three different leadership orientations as discussed in these paragraphs, present the 'pure nature' of these orientations. But no one is 100% Task, Relation-, or Self-oriented.[394] In that respect Kotter[395] suggests that effective leaders probably use a mix of different types of power. The resulting leader is a mix of the three orientations, showing a predominant one. But this dominance may change due to external situational influences. As Yukl argues: "Where there is extreme pressure to perform a difficult task or to survive in a hostile environment, the role expectations for the leader are likely to change in a predictable way."[396] Supporting Yukl, Post specified this by suggesting that leaders' behaviour as usually exhibited under 'normal' operational conditions may change into a compulsive, paranoid, or narcissistic type of behaviour.

The main objective of this research is to study the relationship between leaders' behaviours and the prevention of safety incidents. By finalising these paragraphs about leadership, leaders have been profiled in a way that they can be recognized as Task, relations-, or Self-oriented. In our research we will employ these three orientations to establish whether and if so, in what way, leaders of certain behavioural orientations indeed influence the prevention of safety incidents.

392 Post (2004).
393 Rosenthal and Pittinsky (2006).
394 Dweck (2012).
395 Kotter (1982).
396 Yukl (2010), p. 92.

2.4 Operational context

Safety incidents arise in a complex environment, where organisational, situational, physical and socio-psychological circumstances sometimes interact in an unforeseen way. In the following sections we will elucidate some salient aspects of this context. First, we present the organisational frameworks (in legal as well as operational terms) in which primary processes operate. We then give a (very limited) overview of case histories, where primary (typically) processes deviated from their intended courses and 'derailed'.

2.4.1 *Organisational frameworks*

Organisations operate in two significant and different contextual frameworks: an external *legal* framework and an internal *operational* framework.

De Vries describes an approach which connects the two frameworks by introduction of the concept of 'vulnerability.'[397] In his work he argues that the meticulously regulated world we live in is not as safe as we would like. There are still 'unknown unknowns', safety risks, which organisations encounter in their daily operations and which are not covered by legislation.[398] In order to prevent business interruptions, organisations take measures upon discovery of these new risks even before the law forces them to take preventive action. Only later, after the 'unknown unknowns' have become 'known knowns', legislators react on these 'new' risks by the development of new regulations.[399] This is an interactive process and intertwines the two frameworks in which leaders of organisations have to find their way.

2.4.1.1 The legal framework

Leaders, by law as well as morally, are ultimately responsible and considered accountable for the occurrence of adverse events and consequences of safety incidents.[400, 401, 402]

But is that a reasonable requirement? Are leaders actually capable and sufficiently informed to enable them to prevent safety incidents? Do they, in case of unconfirmed weak signals of unsafety, want or dare to intervene in seemingly smooth-running production processes?

Rasmussen suggests that: "In spite of all efforts to design safer systems, we still witness severe, large-scale accidents."[403] The Netherlands, the research area of this study, is not an exception to that: safety incidents, albeit irregularly keep occurring.[404] Apparently,

397 De Vries, Verhoeven and Boeckhout (2014).
398 Ibid.
399 Ayres and Braithwaite (1992).
400 Braut and Lindøe (2010).
401 Eisenberg (1989).
402 Leistikow (2010).
403 Rasmussen (1997), p. 183.
404 Onderzoeksraad voor Veiligheid (2013d).

many organisations are not sufficiently in control of their operational processes. Incident analyses show that often leadership plays a prominent role in the cause of safety incidents. In order to protect leaders from legal proceedings and prosecution, organisations should make all possible efforts to ensure an effective conduct of state-of-the-art risk management methods and techniques.[405, 406, 407, 408]

The legal framework defines obligations, responsibilities and accountabilities from an external, governmental point of view. This section suggests that in the 1980s an intended deregulation of legislation created a legislative vacuum, which has been filled by extensive, newly developed accreditation and certification rules. We take the position that the legal transformation process has not resulted in a reduction of the gap between the 'paper world' and the 'real world.' Often, compliance with legislation is limited to a level where leaders of organisations deem this necessary to keep their 'licences to operate.'[409] Also, we argue that, due to the increased complexity of primary processes, the current practice of self-regulation and compliance provides insufficient reason to rely on the self-cleaning capacity of organisations.[410]

In every socio-cultural environment, organisations have to deal with society's and political expectations where it concerns the prevention of safety incidents. In order to regulate that interactive process, a legal framework governs the way organisations manage their safety risks. In the countries where the observed safety incidents occurred (the Netherlands, United Kingdom and the United States of America) the legal systems contain rules and regulations governing the responsibility for the prevention of accidents in organisations (safety regulations). All of the organised operational processes referred to are subject to the jurisdiction of legal frameworks, like for occupational safety, the Arbeidsomstandighedenwet, which is based on the European OSH Framework Directive 89/391/EEC and similar legislative frameworks concerning the quality of occupational safety management systems (e.g., the Nederlands Technische Afspraak (NTA 8620:2016, 'Specification of a safety management system for major accident hazards'), which aim to prevent safety incidents in the different sectors subject to this study.[411, 412, 413, 414, 415]

In this respect, the health care sector takes a special position; besides managing safety risks to health care workers (occupational safety), managing the safety risks to hospital patients is also regulated. To that purpose, specific legislation has been developed. The 'Wet kwaliteit, klachten en geschillen zorg' (law on quality, complaints and healthcare

405 Onderzoeksraad voor Veiligheid (2007).
406 Onderzoeksraad voor Veiligheid (2008b).
407 Onderzoeksraad voor Veiligheid (2012).
408 Onderzoeksraad voor Veiligheid (2013c).
409 Kluin (2014).
410 Erp, Huisman, Bunt and Ponsaers (2008).
411 Arbeidsomstandighedenwet (1980).
412 BRZO (1999).
413 Spoorwegwet (2005).
414 EU OSH Framework Directive 89/391/EEC (1989).
415 NEN (2016).

disputes) is the central part of that legislation.[416] In addition, the sector has developed a specific standard concerning patient safety management systems (NEN 8009:2018, 'Safety management system for hospitals and institutions that provide hospital care').[417] Also the health care sector itself develops and issues professional guidelines on an ongoing basis. Until 1999 the health care sector was rather passive with respect to patient safety, but the publication of the report 'To Err is Human' served as a wake-up call.[418] Since then, the sector has caught up and at present health care-related legislation and patient safety systems are of an innovative nature.[419]

Addicted to bureaucracy

In the 1930s, Heinrich[420] proposed that the organisation of the responsibility for safety should follow a similar hierarchical structure to the way responsibilities for the primary production process are organised. That proposal has been followed by many organisations and this approach is still reflected in current health and safety legislation of many countries.

Roughly 50 years later, Bennis predicted the end of 'bureaucracy as we know it.' He claimed that hierarchical structures will be replaced by new social systems better suited to the demands of the twentieth century industrialisation, because the 'Heinrich way of organisation' will be out of joint with contemporary realities then.[421] However, in his book *Safety Management, A Human Approach* (2001), Petersen explains that the typical present-day safety programs still follow the pyramidal-hierarchical organisation as proposed by Heinrich over 70 years ago.[422]

In this respect, it is interesting to notice that Bennis' vision, which predicted rapid change, growth in size and complexity requiring diverse highly specialised ability, was quite correct, but his claim that the predicted changes would lead to the end of bureaucracy has not been realised. Indeed, already in the early 1970s, Lord Robens in the UK proposed replacing prescriptive legislation with an all-encompassing requirement that employers ensure the safety risks of workers 'as low as reasonably practicable' (ALARP). This proposal has been accepted by the regulators in the UK and subsequently enacted in many other countries.[423] In 1980 health and safety legislation in the European Community member states was generalised from prescriptive to goal-setting type regulations. Throughout the European Community, this has resulted in replacing old prescriptive legislation with new, goal-setting legislation.[424] Nevertheless, Bennis' predictions did not come true; bureaucra-

416 Wet klachten en geschillen in de zorg (2016).
417 NEN (2018).
418 Brown and Patterson (2001).
419 Leistikow (2010).
420 Heinrich (1941).
421 Bennis (1989).
422 Petersen (2001).
423 Hopkins (2006).
424 Arbeidsomstandighedenwet (1980).

cy in the regulation of safety has not been reduced at all. On the contrary: since the early 1980s, a clear tendency towards the proliferation of formal law is observed.[425] Prescriptive text has been replaced by e.g., requirements to set performance criteria, which give room for interpretation and are therefore hard to operationalise univocally.

According to Hopkins, there is a difference regarding the type of decision in relation to the level of detail of regulations. The dichotomy that exists is that on a non-operational level (a.k.a. 'blunt end'), decisions are taken based on risk analysis and that on an operational level (a.k.a. 'sharp end'), decisions are taken based on rule-compliance.[426] Consequently, operational people need clear specific rules in order to know what to do to ensure continuation of the primary process. But these prescriptive instructions have been withdrawn and the transfer to goal-setting regulations has created uncertainty and unexpected room for individual preferred solutions of safety issues. As a reflex to this unclear situation, the desire appeared to eliminate the indistinctness and regain clear criteria. Thus, private organisations and industrial sectoral associations rehabilitated old prescriptive rules, which had been declared void by the government.[427, 428]

We wondered whether an elementary transformation of the European legal system as described above had influenced the organisations' focus on safety-related subjects. And we assumed that, in case this is true, it could have caused certain fluctuations in the literature about risk, safety and the legal discipline. In order to verify that, we generated a n-gram visualisation of the frequency of word-use in the English language during the period from the beginning of the 19th century until the year 2000. In Figure 20 below, the frequency of the use of some key terms, which are considered relevant in this context are visualised.

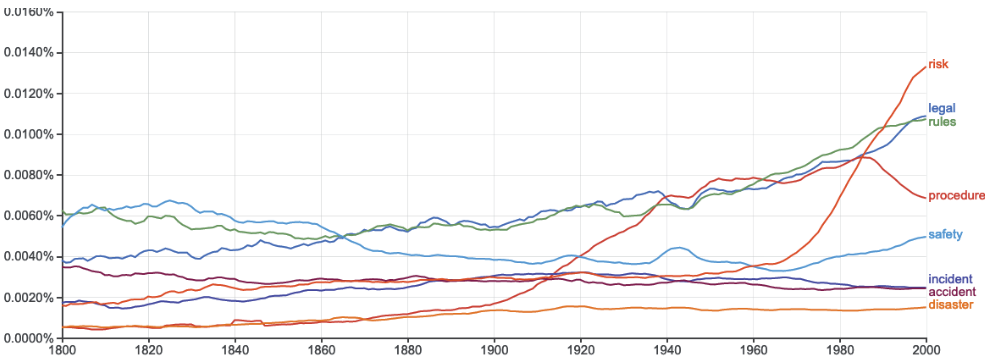


FIGURE 20 Word-use of risk management related terms in literature

The referred transformation in European safety legislation from prescriptive into goal-setting regulations took place in the early 1980s; nevertheless, the increase of use of

425 Teubner (1987).
426 Hopkins (2011).
427 Peuscher and Groeneweg (2012).
428 Walker, Throndsen, Reeves, Hudson, Croes, Dahl-Hansen, Stadler and Winters (2010).

the terms 'legal' and 'rules' continued until the year 2000 at the same pace as happened in the preceding 100 years. Since the 19^{th} century, the use of the term 'procedures' has also shown a similar increase. But in the 1980s this steady increase reversed, resulting in a steep decrease in the use of 'procedures.' The fact that this decrease coincides with the withdrawal of many prescriptive procedures from the European legislation is probably no coincidence. Since the 1970s, an increase in use of the term 'safety' is observed and also the use of the term 'risk' shows a steep increase since then. Regarding these terms, an ongoing increase in focus is recognised. Of special interest is our observation that none of the mentioned fluctuations in the use of the referred terms has had a significant effect on the use of the terms 'incident', 'accident', or 'disaster.'

We conclude that deregulation has resulted in a steep decrease in procedures, but it has not stopped the steady increase in rules and legislation. Also, a consistent increase in focus on risk and safety is visible. But despite the observed fluctuations in literature, we did not observe any influence where it concerns the words 'incident', 'accident' and/or 'disaster.'

The European drive away from prescriptive to goal-setting legislation may have reduced the use of procedures, but it also created a boost on a secondary level of juridification, which possesses a quasi-legislative character. This concerns new rules related to e.g., certification and accreditation of goods and services. Part of that change was the obligation for organisations to acquire health and safety-related support from accredited independent enterprises (Arbodiensten). This requirement generated new standards in order to enable certification of these health and safety service providers.[429] Consequently, the governmental requirements for the development and certification of safety management systems and safety cases created a formal position for private certification bureaus (a.k.a. independent bodies) in an attractive new market place.[430] Tangible certification requirements and other measurable performance indicators have been developed and these have more than replaced the void prescriptive governmental regulations. We illustrate this statement with some examples:

Nowadays all machinery, instrumentation and materials must be CE-certified, technical staff are required to be NVQ certified, health care workers are registered in a national (BIG) register, health care centres like hospitals and nursing homes are certified (e.g., HKZ, Joint Commission International) and many workers have attended compulsory basic safety or in-house emergency services (BHV) training courses, for which attendance is proven by the stamps in their 'Personal Safety Logbooks.' The company's safety achievements may be established by measuring the achieved level on the culture ladder.[431, 432, 433, 434, 435]

Even a dentist is allowed to install dental implants only if these implants are CE-certi-

429 Gerlings and Hale (1991).
430 Zwetsloot, Hale and Zwanikken (2011).
431 Ahaus (2008).
432 Biesaart (2010).
433 Soree (2007).
434 Sreenivasan, Benjamin and Price (2003).
435 Zwetsloot, Bezemer and De Hoog (2012).

fied, which should warrant that the implant meets the essential requirements for safety, effectiveness and health.[436] The above examples are images of the paper world mankind has created.

A paper world

For regulators as well as operating organisations, clarity has now returned: safety performance has returned to paper! So, it has become auditable again; stamps and certificates serve as proof of being safe. This is exactly what leaders need in order to obtain the comfortable feeling of control.[437, 438]

But history has proven that that is a false feeling of comfort, as reality shows a different picture; in all sectors referred to in this dissertation, efforts to reduce safety risks by accreditation and certification systems have not been effective.[439, 440, 441, 442, 443, 444, 445, 446, 447, 448]

Kluin identified that organisations clearly understand that compliance with regulations is a necessity to maintain their licences to operate, but she also indicates that the observed compliance is an optic phenomenon only, which is not equal to effective risk control.[449] So, the bureaucratic reflex and subsequent certification and internal juridification drives after the transfer from a prescriptive to a goal-setting regime may have delivered the desired clarity on paper, yet to date, it has not led to the desired level of operational risk control.[450] Apparently, the paper world gives people a feel-good experience. However, with awareness of its actual limited effects on risk reduction, the challenge is to find different ways to convince people, leaders and followers that, in order to improve risk reduction, a different type of attention is needed.[451]

Inspectorates

Governmental inspectorates are aware of that reality and try to keep an eye on what happens in day-to-day life in operational processes. Policing governmental departments

436 Verdonschot (2008).
437 When asked to pinpoint his USP (Unique Selling Proposition), the manager of a safety training centre answered: “We facilitate the manager’s night rest!” (Personal communication, 2002).
438 Groeneweg, Hudson, Vandevis and Lancioni (2010).
439 Onderzoeksraad voor Veiligheid (2005).
440 Onderzoeksraad voor Veiligheid (2007).
441 Onderzoeksraad voor Veiligheid (2008b).
442 Onderzoeksraad voor Veiligheid (2008a).
443 Onderzoeksraad voor Veiligheid (2011).
444 Onderzoeksraad voor Veiligheid (2012).
445 Onderzoeksraad voor Veiligheid (2013a).
446 Onderzoeksraad voor Veiligheid (2013b).
447 Onderzoeksraad voor Veiligheid (2013c).
448 Onderzoeksraad voor Veiligheid (2015).
449 Kluin (2014).
450 Here we refer to the results as presented in the n-gram (Figure 20).
451 Bieder and Bourrier (2013).

conduct inspections and audits to remind organisations of their duties. But the effectiveness of these inspections and audits is limited. The fields to be inspected are too wide, technologies are too complex and innovations are developing quickly and on a continuous basis.[452] The quantities and competences of inspectors are far too limited to ensure that all accidents are prevented.[453]

Therefore, it is not realistic to expect that rules and regulations be fully enforced. Full coverage is impossible and, from a preventive point of view, it is not realistic to expect sufficient capacity in governmental inspectorates to ensure the prevention of all types of safety incidents. Compliance depends a great deal on the leaders and the professional experts who reside inside the organisations where safety risks are present and who know how to control their safety-critical processes.

In addition, the technology behind these processes develops in a fast pace and contains, also due to the protection of intellectual property, more and more unique and complex features. Also, in the present competitive environment, organisations tend to shield off the particularities of their innovative findings. In that setting it is unrealistic to expect that governmental inspectorates are capable of identifying every detail of hazardous primary processes and its ensuing safety risks.

In reaction to losing governmental prescriptive guidance, some sectors have developed sector-specific risk management systems, which organisations/members of the sector's professional association are bound to comply with. These systems address sector-related safety and operational issues and sector-wide comparison of compliance levels stimulates organisations to become 'best in class.' In this way, organisations obtain/maintain their licences to operate by convincing the authorities that the safety risks of the intended operation are managed according to their own sector standards and that these risks do not exceed the ALARP[454] level. The development of these systems is a clear example of how deregulation has triggered a shift in the supervising role from governmental inspectorates to private organisations.

However, like in other situations described above, it is noticed that supervising authorities shift their focus to the non-operational level by imposing additional guidance. This guidance primarily amounts to further sets of rules about how decisions are to be made in complex situations.[455] But, how are inspectorates dealing with inherent 'uncertainty'?

Concerning this phenomenon, the European Commission has issued clear legislation. This refers to the so-called 'precautionary principle', which is to be applied in cases where organisations are not able to assess safety, environmental and health risks with a sufficient degree of exactitude. Although most publications show that this European legislation refers to environmental protection, this legislation is not limited to this domain

452 Bratspies (2011).
453 Popma (2011).
454 As Low As Reasonably Practicable.
455 Hopkins (2011).

only and safety and health are indeed mentioned, but not as explicitly as the environmental related text.[456]

The concept of 'uncertainty' has not yet been addressed widely; nevertheless, increased complexity of primary processes supports the idea that uncertainty will be subject to future discussions between inspectorates and leaders of organisations and in future even may be applied to elucidate, defend, or accept the development of safety incidents.

The law and the role of leaders

Realistically spoken, where it concerns the prevention of safety incidents, compliance with legislation is not considered a 'silver bullet'; the effectiveness of risk control merely depends on the way the organisation itself is taking care of their primary processes.[457] Moreover, not all decision-making can be converted into procedures and there will always be situations which are not formally regulated or where quick decisions are needed in order to remain safe and where individuals need to trust their own expertise to assess operational safety risks and act on their own account.[458, 459]

In the end, where it concerns the undisturbed continuity of production, the organisation itself is the primary stakeholder. Inside organisations reside vocational expertise, operational skills and knowledge of the primary processes, with their embedded hazards. This is where the leaders on all levels appear as the individuals responsible for optimally meeting the legal 'duty of care.'[460]

The next section will discuss the operational contextual situation in which leaders are expected to fulfil this obligation.

2.4.1.2 The operational framework

The previous section discussed the 'paper world'; this section is about dealing with the 'real world.'

The operational framework defines tasks, responsibilities, authorities and interrelations of the members of the organisation from an internal point of view, supported by the shareholders of the organisation. If an organisation has assigned accountabilities to the right, most competent people, it has a preventive effect for safety.[461] Here, continuity of the primary process and prevention of operational disturbances are the central themes.[462, 463]

456 European Commission (2000).
457 Erp, Huisman, Bunt and Ponsaers (2008).
458 Hopkins (2011).
459 Weick and Sutcliffe (2007).
460 Eisenberg (1989).
461 Wetenschappelijke Raad voor het Regeringsbeleid (2008).
462 Groeneweg (1992).
463 Muller E.R. (2012a) .

The real world

For reasons of efficiency and effectiveness, activities take place in an organised form, called a *system* or *organisation*. Each system has its specific goals and objectives, like making profit, healing ill people, or transporting people or cargo from A to B.[464] Safety risks are inevitable side effects of these goals.[465] Fischhoff argues that "hazards begin with the human need the technology is designed to satisfy and develop over time."[466] Perrow[467] argues that most high-risk systems have some special characteristics that make accidents inevitable, even *normal*. Moreover, he states that for safety reasons certain technologies should be abandoned, but that is impossible, because "we have built much of our society around them."

In this simultaneously stimulating and sometimes constraining operational environment, people conduct a balancing act in finding an incident-free way to achieve their goals and objectives. Many times, we embrace the pros and compromise the cons of something, simply because we like or need it; generating electrical power pollutes the atmosphere, exploring hydrocarbons depletes oil and gas reservoirs, oil tanks emit poisoning vapours, trains collide and health care can be fatal to hospital patients, etc.

Operational disturbances (unintended mishaps in an intended operational process) may, if safety risks are not identified and sufficiently controlled, evolve into events with (potentially) disastrous consequences.[468]

Leaders in organisations direct their subordinates in the desired direction in order to accomplish the intended organisational goals. By law, the task of the leader is also to ensure that operational disturbances that have potential for safety incidents to occur are prevented.[469] But since, according to Beck, in the classical industrial society the 'logic' of wealth production dominates the 'logic' of risk production, the letter of law does not always suffice to motivate people where it concerns compliance.[470] Organisations operate in an environment of incompatibilities; people, planet and profit are competitive concepts and sometimes complying with safety regulations may conflict with these priorities.[471] In such situations it is not always easy for people, on managerial, on tactical, as well as on operational levels, to prioritise safety over other operational aspects.[472]

According to risk management theory, human error plays an important role in the causation of accidents.[473] The contextual situation in which people conduct their occupational activities is of important influence on the probability that these people may err.[474]

464 Hale and Glendon (1987).
465 Beck (1986).
466 Fischhoff and Lichtenstein (1984), p. 10.
467 Perrow (1999), p. 4.
468 Reason (1997)
469 Ibid.
470 Beck (1986).
471 Kluin (2014).
472 Erp, Huisman, Bunt and Ponsaers (2008), ibid.
473 Groeneweg (1992).
474 Rasmussen (1997).

In many cases, people work under unfavourable contextual situations and may be tempted to err and thereby contribute to the occurrence of a major incident. Consequently, it is the role of the leaders to create and maintain favourable contextual situations in order to reduce the probability of human error to a minimum. But causation of safety incidents is much more complex than a combination of good and wrong human acts resulting in success and/or failure. Where we are fairly well able to investigate and analyse the causes of individual accidents, we do not yet know how to manage the risks that may lead to a major incident.[475] In order to enhance understanding of the safety incident causation process, in the next sections, relevant key factors in incident causation are discussed.

2.4.1.3 The primary process

The primary process of an organisation is its 'reason to be.' It is the way one works towards predetermined economic or social added value. In the Oxford dictionary a 'process' is defined as 'a series of actions or steps taken in order to achieve a particular end'.[476] Also, a process means 'change' and/or 'creation.' In the context of this study, the 'primary process' encompasses the activities required to generate value to all stakeholders concerned. However, apart from this intended positive effect, a primary process may generate unwanted safety hazards. The primary process is considered to be the place where hazardous energy, or sufficient cause is 'waiting to escape' in an uncontrolled manner.[477] These hazards can be considered by-products that need to be controlled to prevent a safety incident and its consequential loss, damage and/or injury. Risk reduction measures, such as a safe design, risk identification, risk analysis procedures (e.g., HAZID, HAZAN and HAZOPS), inspections, audits and preventive maintenance, are developed to ensure that trapped energy will not escape in an uncontrolled way and cause damage or injury. People are also instructed and trained to operate the primary process according to Standard Operating Procedures (SOP), and are prepared to recognise and manage operational disturbances through contingency planning and emergency procedures.

In this study, which focuses on the sectors of oil and gas, tank storage, hospitals, rail and general infra and general industry, the following processes are examples of 'primary processes': drilling wells to explore oil and/or natural gas reserves, storage of flammable fluids, surgery and administering of medication to hospital patients, track and time control of trains, construction of rail systems and conducting infrastructural and steel construction work. In relation to safety incidents causation, these processes are considered 'risk generators.' Organisations undertake risk management activities to ensure the safety of their respective primary processes. The next sections will explain what is meant by the term 'safety.'

475 Weick (1988).
476 Oxford University Press (1989).
477 Hopkins (2014).

2.4.1.4 Examples of derailed primary processes

This research is about leadership in organisations where serious safety incidents are considered imaginable, or have even taken place already. The following sections list some scene-setting, and illustrative examples of major incidents which have occurred in the sectors covered by this research. These major incidents have been selected according to the following criteria: 1) the variety of these specific domains, 2) repetitive nature of the domain concerned, and 3) relative high community impact.

Safety risks are only related to the specific primary processes in a specific business sector, and not to the geographical area in which the organisations are operating. We made this choice because some of the examples are well-known internationally, and are illustrative as relevant major incidents in this research. Each of the examples shows a state of crisis, either due to singular severe disasters, or multiple, widespread, individual cases. These major incidents meant 'crisis' for both the organisations involved, and the authorities concerned. In general, each of the described cases show how seemingly controlled operations in well respected and safety-concerned organisations have led to major incidents. In each case, a certain severity threshold has been exceeded, causing community interest, press coverage and, consequently, collateral damage to reputation of the organisations involved. Before these incidents occurred, nobody expected these to happen; everyone was convinced that their operation was safe.

The examples are depicted sector-by-sector in the following order: tank storage, hospitals, oil and gas, rail infrastructure, the process industry and general infrastructure.

Tank storage

On December 11, 2005, the town of Buncefield (UK) faced a series of explosions at the nearby hydrocarbon storage facilities. The extremely strong explosions were noticed by the British Geological Survey and recorded as an earthquake measured as 2.4 on the Richter scale. The explosions were reported as audible in France, Belgium and the Netherlands. As a result, 43 people were injured and there was a massive amount of material damage.[478]

During the year 2011, a tank storage terminal in the Rotterdam area (NL) became subject to intensive inspection by different inspectorates due to non-reporting of accidental chemical emissions to the environment. During the inspections, many violations of environmental and safety regulations were found. As a result, the terminal was shut down, employees were laid off and the terminal went broke.[479] Due to a huge financial injection from the owners, the terminal resurrected and was re-started after more than a year under different management; the leaders of the tank terminal were removed and a team of new leaders introduced.

Shortly after the terminal ceased operations, the Health and Safety Inspectorate ordered inspection of 91 different tank farms, randomly selected throughout the sector. At

478 Buncefield Major Incident Investigation Board (2008).
479 Onderzoeksraad voor Veiligheid (2013a).

73 sites a total of 323 violations of environmental and health and safety legislation were detected.[480] In reaction to this, legislation, as well as inspections, were intensified.[481]

Hospitals

Major incidents in industrial and transport sectors show precise numbers where it concerns casualties and injured people. Due to the different nature of the health care profession, the extreme volume of events and the lack of public records, it is not possible to precisely quantify the number of major incidents for this sector. However, in the mid-1990s, extensive studies were conducted in the USA (Colorado, Utah and New York) showing that in the USA, 44,000 (1997 extrapolation based on figures from a Colorado and Utah study) to 98,000 (1997 extrapolation based on figures from a New York study) people die each year as a result of preventable medical errors in hospitals.[482]

The attention to these situations raised serious attention in the year 1999 when the Committee on the Quality of Health Care in America of the Institute of Medicine (appointed in 1998) issued their report 'To Err is Human; Building a Safer Health Care System'. The report marked the completion of a project aimed at the examination of the issues and gave recommendations for rigorous changes in American health care.[483] The report refers to the Colorado, Utah and New York studies, as well as to three medical error cases where patients did not survive their hospital treatments, which made the headlines in the national press. 'To Err is Human' can be considered the book that increased interest in health care safety on a global scale. In order to identify the severity of the problem of medical error in the United States, the book compares the annual amount of fatal occupational accidents (6,000) with the estimated annual number of people dying in or outside hospitals as a result of medication errors alone (7,000).[484]

In 2001, the committee issued a second report, titled 'Crossing the Quality Chasm, a New Health System for the 21st Century'. Where 'To Err is Human' focused on patient safety only, this second report focused more broadly on how the health care delivery system can be designed to innovate and improve care. This report relates to the purpose and aims of the health care system, how hospital patients and their clinicians should relate and how care processes can be designed to optimise responsiveness to patient needs.[485]

The publication of 'To Err is Human' has triggered a response where worldwide health care institutions have extrapolated the American data to their local situations, followed by investigating the actual national numbers of 'preventable deaths' in their own health care systems.

In the Netherlands in the year 2004, 6,000 hospital patients experienced permanent

480 Rijkswaterstaat (2013).
481 Ministerie van Infrastructuur en Milieu (2013).
482 Gawande, Thomas, Zinner and Brennan (1999).
483 Institute of Medicine (1999).
484 Ibid.
485 Institute of Medicine (2001).

health damage by preventable medical errors.[486] A study by EMGO NIVEL reported that in the same year, 1.735 people died as a result of preventable medical errors in hospitals in the Netherlands.[487] Successive studies show that this number increased slightly to 1.960 (in the year 2008) and then decreased to 968 casualties in the period from April 2011 to April 2012.[488, 489] It is suggested that this reduction by 54% was the result of the introduction of a national patient safety campaign (VMS). During the period of April 2015 to April 2016, the reported number of casualties increased insignificantly to 1.035.[490] There is no unambiguous information publicly available about the causality of these deaths and/or about the causality of other deaths not classified as 'preventable.'

Process industry

On June 1, 1974, a chemical plant at Flixborough (UK) was severely damaged by a large explosion caused by leaking cyclohexane. 28 Workers were killed and 36 people injured.[491] The disaster happened one day after the first European Loss Prevention Symposium.[492]

On March 23, 2005, at a hydrocarbons refinery in Texas City (US), a vapour cloud explosion occurred. 15 people were killed, over 170 people were injured and huge damage was caused.[493]

On January 5, 2011, at Moerdijk (NL), the site of a chemical packing company burned down completely. The fire and the way the fire brigade combatted it, resulted in enormous environmental pollution. After the fire, the buildings on the site were totally burned down. There were no casualties. The company went broke.[494]

Oil and gas industry

In March 1980, the semi-submersible accommodation platform Alexander Kielland, located in the Norwegian Ekofisk field, about 400 kilometres east of Scotland, capsized. As a result, 123 crewmembers drowned; only 89 of 212 workers survived the accident.[495, 496]

In the evening of July 6, 1988, the oil and gas industry was struck by an explosion and consecutive fire on the Piper Alpha offshore production platform, located 193 kilometres North East of Aberdeen (UK); as a result, 167 oilfield workers died.[497]

On May 21, 2005, at Warffum (NL) a storage tank containing natural gas condensate

486 Van Velthoven (2008).
487 De Bruijne, Zegers, Hoonhout and Wagner (2007).
488 Langelaan, Baines, Broekens, Siemerink, Steeg, Asscheman, De Bruijne and Wagner (2010).
489 Langelaan M., Baines, Broekens, Hammink, Schilp, Verweij, Asscheman and Wagner (2013).
490 Langelaan, Broekens, de Bruijne, de Groot, Moesker, Porte, Schutijser, Singotani, Smits and Zwaan (2017).
491 Venart (2004).
492 Swuste (2022), p. 183.
493 Hopkins (2008).
494 Onderzoeksraad voor Veiligheid (2012).
495 Braut and Lindøe (2010).
496 Moan (1981).
497 Cullen (1990).

exploded during welding work; as a result, 2 technicians died.[498]

On April 20, 2010, the well blew out on the semi-submersible drilling rig Deepwater Horizon in the Gulf of Mexico. The unit caught fire and sunk. As a result, 11 oil workers went down with the sinking rig and drowned. The well spilled 4.9 million barrels of crude oil into the sea, polluting the water and the Texas coast line, destroying the local fishing industry at the coast of the Galveston and Houston area.[499]

Rail infrastructure

On January 8, 1962, near the village of Harmelen (NL), two passenger trains collided head-on in thick fog. As a consequence, 93 people died and 52 people were injured.[500] This railway accident served as the trigger to install automatic brake control systems (ATB) in all trains in the Netherlands.

On November 30, 1992, a passenger train derailed in the vicinity of Hoofddorp (NL). As a result, five passengers died, more than 30 passengers were injured and there was massive material damage. This railway accident served as one of the triggers to install a National Railway Accident Investigation Board, the predecessor of the Dutch Safety Board.[501]

On April 21, 2012, two passenger trains collided head-on in the vicinity of Amsterdam Central Station. As a result of that, one passenger died. This accident initiated an extensive political debate about the safety of railway traffic. [502]

General infrastructure

On October 21, 2010, in Rotterdam, a concrete floor of a high-rise building under construction collapsed due to lack of stability in the temporarily support scaffolding under the floor being fabricated. During the building process, the scaffolding was not constructed as per the design. Five people were seriously injured and the material damage was extensive.

On May 27, 2017, part of a parking garage at Eindhoven airport collapsed one month before the building was planned to be opened. Deviation from the standard design of the floor construction decreased the structural integrity of the floors. Expansion of the floor elements due to high ambient temperature resulted in an overload of the floor sections and the consequent collapse. This incident resulted in massive damage to material and the company's reputation. No personal injury was reported.

On May 27, 2017, a road construction worker fell from a viaduct in Amstelveen (NL). The day before the incident, the outline of the fall protection boarding had been changed. This created a situation where workers had to position themselves outside the protected

498 Onderzoeksraad voor Veiligheid (2007).
499 White, Hsing, Cho, Shank, Cordes, Quattrini, Nelson, Camilli, Demopoulos, German, Brooks, Roberts, Shedd, Reddy and Fisher (2012).
500 Raad voor de Transportveiligheid (1999).
501 Hansen (2012).
502 Onderzoeksraad voor Veiligheid (2013c).

area in order to do their work. The victim died due to the injuries caused by the fall.

In this chapter the theories, concepts and operational context regarding the core aspects of this research, risks, safety and leadership, have been discussed. Next, we will explain the scope, research queries, design and methodology of the empirical research in order to discover the resolution of the principal query of this research; if and if so, in what way, to what extent leaders can help to prevent of safety incidents.

Reversibility suggests that 'leaders' know who they are through the eyes of 'followers' and, likewise, 'followers' can only know themselves as 'followers' through the eyes of their 'leaders'.

DONNA LADKIN

3 Empirical research

In this chapter we present the scope of the study, our basic assumption, the principal research question and related sub-questions and the design and methodology of this research.

3.1 Scope of the study

This research refers to the primary processes of private as well as public organisations; that is, processes performed to achieve the conversion or transformation of source materials, data or services in order to achieve certain monetary or social objectives. According to the Oxford Dictionary, an organisation is considered '*an organised group of people with a particular purpose*'.[1] When we use the term *organisation,* we assume the presence of a certain structure, where leaders steer people conducting operations in order to achieve pre-defined goals.[2] We focus on organisations operating in different business sectors in the Netherlands. These organisations cover the following six specific business sectors: tank storage, hospitals, oil and gas, rail infrastructure, process industry, general infrastructure and one general sector, called 'other'.[3] These sectors have been selected because their primary processes are 'safety-critical' and include relatively high safety hazards and are therefore considered vulnerable to safety incidents leading to major consequences.[4, 5] Also, these sectors are considered as relatively mature where it concerns their policies and practices to prevent operational disturbances. These organisations are operating in different sectors and their specific types of risk are considered to be of different natures as well. This means that their individual risk management practices, which may work well in their own organisation or sector, may not be effective at all in the different setting of another organisation or sector.[6] However, in all sectors concerned, the primary objective of risk management is identical: prevention of safety incidents by managing safety risks.

1 Oxford University Press (1989).
2 Hale and Glendon (1987).
3 The group 'other' is a mix of respondents whose sector did not match any of the other six sectors.
4 Onderzoeksraad voor Veiligheid (2013d).
5 Venema, Den Besten, Klauw and Ybema (2013).
6 Guldenmund (2010).

In our research we consider the leader in their position as an individual, responsible for ensuring the sufficient control of processes and prevention of incidents, as a preventer of accidental events. This is about the ways in which leaders lead their people, and the effectiveness of their leadership where the management of safety risks and prevention of safety incidents is concerned. Contingency planning or emergency responses provided after a safety incident has occurred are outside the scope of this study. In order to determine the contribution that leaders make to incident prevention, we will approach their role from a prospective as well as a retrospective point of view.

3.2 Basic assumption

Many different safety risks are associated with the various primary processes of different organisations. These risks are inherent to the work of these processes and do not disappear by themselves, but risk can be reduced by taking measures.[7] The process aimed at reducing risks is called risk management. To execute this risk management process in an optimal way, leaders need to create a safe environment in which their team members are prepared to support them in their efforts to prevent operational disturbances.[8] The way in which leaders influence their subordinates determines whether their followers are willing to co-operate or not. This willingness depends a great deal on the people's perceptions of safety. As a basic assumption, however, *we assume that leaders play a key role in preventing safety incidents*.

3.3 Research enquiries

As enforced in Dutch legislation (e.g., Arbeidsomstandighedenwet, comparable with the UK Health and Safety at Work Act), the responsibility for accident prevention in organisations lays primarily with the people who are considered to control the organisations' operations, i.e., the individuals occupying the highest hierarchical position in those organisations (CEOs and the like), who may appoint other leaders (managers and supervisors) to assist them in the fulfilment of their obligations.[9] This implies an interesting paradox: on the one hand, we assume that all people involved in organisations are committed to undisturbed operations, working in well-controlled processes resulting in an optimal output. On the other hand, we see that these operations themselves generate safety risks resulting in material damage, personal injury and economical/reputational losses. Here, conflicting demands for leaders seem to appear.[10] Based on these seemingly incompatible goals, we wonder how leaders cope with these dilemmas and what kind of trade-off decisions they will make.

7 Ale, Baksteen, Bellamy, Bloemhof, Goossens, Hale, Mud, Oh, Papazoglou, Post and Whiston (2008), p. 182.

8 Edmondson (1999).

9 Arbeidsomstandighedenwet (2004).

10 Dekker, Hollnagel, Woods and Cook (2008).

3.3.1 *Principal research query*

Our research is about the role of leaders in preventing accidental events in their position as the individual responsible for ensuring the sufficient control of processes and prevention of incidents. This is therefore about the way leaders lead their people and the effectiveness of their leadership where the management of safety risks is concerned. Contingency planning or emergency responses provided after a safety incident are outside the scope of this study. This study's principal research query is thus: *"Can leaders of organisations help to prevent safety incidents?"*

3.3.2 *Research questions*

In order to resolve the principal research query stated above, we proposed the following questions regarding the relationships between leaders, safety and risk:

1. Does risk reduction relate to safety in organisations?
2. Do the behavioural orientations of leaders relate to risk reduction?
3. Do the behavioural orientations of leaders therefore relate to safety in organisations?

3.4 Research design

This study was conducted in the following business sectors: tank storage, hospitals, process industry, oil and gas exploration and production, general infra, rail infra and general industries. All participating organisations are based in the Netherlands. Regarding safety incidents, the primary processes in these sectors are considered to carry 'high safety risks', potentially resulting in major incidents threatening people, assets and/or the continuity of primary processes. This consideration was confirmed by 46% of the respondents, who indicated that in their organisation a safety incident leading to multiple fatalities could occur; additionally, 22% of the respondents suggested that a safety incident resulting in a single fatality or major damage to assets, pollution of the environment, or damage to the organisation's reputation could happen in their organisation. In these organisations we acquired data related to safety leadership, risk management and safety characteristics. These data were acquired in five different stages: stage 1. an online prospective survey; stage 2. reflection on the outcomes of these surveys by senior leaders; stage 3. retrospective analyses of case history; stage 4. interviews with risk analysis experts about the quality of risk analyses; and stage 5. a review of incident investigation reports as published by the Dutch Safety Board. The data acquisition period covers the timespan from March 2016 until October 2019.

3.5 Methodology

In the next paragraphs an overview of the methods used during the data acquisition process is presented.

3.5.1 *Prospective study*

Stage 1: Online prospective survey

Prospective data is collected to reveal the role of leaders in conjunction with the general state of safety in organisations. An online prospective survey used questionnaires designed to establish the perception of general employees about the degree of risk reduction, the behavioural orientations of their leaders and the perceived level of safety of the organisations the respondents are working in.

Before conducting this survey, we conducted a pilot survey among a group of 99 professional safety experts. The data generated by these experts served to verify the design of the questionnaire and test the Safety Leadership Model. The initial survey questionnaire, as used in the pilot survey, contained questions to discover the respondents' perceptions of the level of risk reduction, as well as of their leaders' behaviours. After analysing the pilot survey data, the Safety Leadership Model was upgraded and the online questionnaire was extended with questions about safety. The finalised online prospective survey was then conducted among a total of 4561 respondents, working in 33 organisations, active in six specific business sectors.

Stage 2: Reflections by senior leaders

After analysis of the survey data from the questionnaires, interviews were held with selected leaders, CEOs, operational managers and safety managers, to collect their reflective opinions on the analysis results.

3.5.2 *Retrospective views*

Stage 3: The view of incident investigators

A case history analysis was performed in order to determine the level to which, and in what way, leaders have influenced the causation and/or escalation of different major incidents ('low frequency/high severity incidents'). This retrospective approach is specifically intended to reveal the contribution of leaders' behaviours and the flaws in risk management in organisations where major incidents have occurred, in comparison with the general safety state as found via online prospective surveys among all the organisations considered.

A group of 18 professional incident investigators individually reviewed existing analysis reports of 19[11] different major incident, with a focus on the specific leadership orientations of the leaders involved, as well as on the risk reduction phases being compromised.

11 One investigator delivered two reviews.

These incident investigators were selected on basis of their qualifications and experience as safety professionals, as well as their experience in the field of incident investigation. The following selection criteria were applied: experience as a safety professional, experience as an incident investigator, number of incidents investigated, business sectors in which incidents were investigated, and investigation tools applied. An overview of these parameters for each investigator is shown in Appendix 15.1, Qualification Information Incident Investigators. Based on the outcome of these reviews, we related the influence of leaders (expressed in leadership orientations) to the identified compromised risk reduction phases. This resulted in a retrospective view of the role of leaders in safety incidents.

Stage 4: The view of risk analysis experts

As awareness of risks is the first step in risk reduction, the recognition of risks is considered an important element. This applies especially where there are high risks with the potential for major incidents affecting the fundamental values of an organisation. After analysing the final survey data, we considered it useful to obtain an independent picture from the professionals about the quality of risk assessments in organisations in which high risk primary processes are carried out. We therefore conducted interviews with five professional risk analysis experts and questioned them about the quality of risk-assessment methods as practised in 'major hazard' (BRZO) organisations, in order to verify the risk analysis-related aspects of the data gathered by the online survey. The knowledge and operational experience of these risk analysis experts was utilised to put the data into perspective, and to draw relevant conclusions.

Stage 5: The view of the Dutch Safety Board

The Dutch Safety Board was established as an independent investigation body, charged by law with investigating and analysing safety incidents in the Kingdom of the Netherlands.[12] It is their mission to contribute to safety improvement in the Netherlands. The role of the board is thus a retrospective one: it investigates major incidents after these have taken place and draws lessons based on their analyses. The board has no responsibility for prospective analyses.[13] The Dutch Safety Board is concerned with the investigation of major incidents in different business sectors in the Netherlands. We reviewed twelve of the board's reports with a special focus on the contribution of risk assessment in the development of major incidents. This review served as the third retrospective approach to analysing the contemporary quality of the understanding of risk in different business sectors.

This chapter described the different elements of the empirical research. The next chapter discusses the development of a Safety Leadership Model and provides each of the core notions (safety, risk management and leadership) with specific characteristics.

12 Rijkswet Onderzoeksraad voor veiligheid (2004).

13 Ibid.

> Leadership is a bit like 'good art' – we may have difficulty in defining it, but we know it when we see it (or experience it).
>
> DAVID PARDEY

4 Safety Leadership Model

In this chapter we will place the three core notions of this research into a three-nodes Safety Leadership Model. We also will specify the characteristics of each notion and utilise these to upgrade the model.

4.1 Safety Leadership Model Version 1

We developed a 'Safety Leadership Model' to discover the actual influence of leaders in the reduction of safety risks, as well as in increasing safety. This model represents the hypothesised ways in which leadership, mediated by risk management as well as directly, affects the safety of the primary process of organisations. We elaborate on this Safety Leadership Model, showing the mutual relationship between the behaviours of leaders, risk management and safety. Figure 21 below shows the *Safety Leadership Model Version I*.

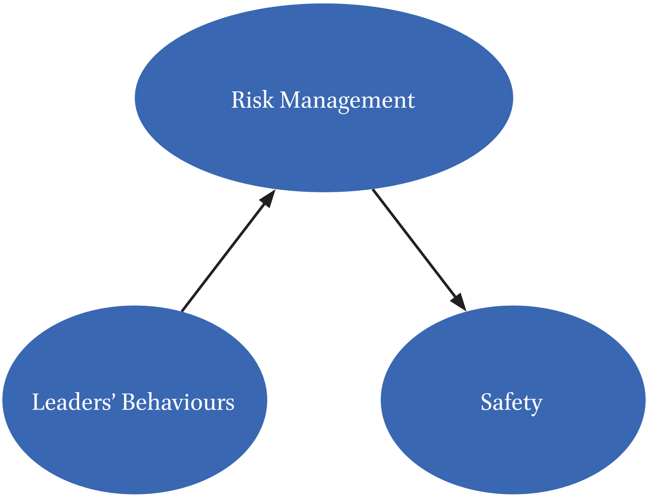


FIGURE 21 Safety Leadership Model Version I

This model, containing the Leaders' Behaviours, Risk Management and Safety nodes, forms the basic structure of the online prospective survey, employed to acquire proactive data about the way leaders influence safety in their organisations.

This Version I of the Safety Leadership Model includes two arrows; one arrow representing the hypothetical influence of leaders' behaviours on risk management, and another arrow representing the hypothetical effect of risk management on safety. These arrows depict the processes behind the central query of this research: "Can the leaders of organisations help to prevent safety incidents?" (ref.3.3)

Following the development of the Safety Leadership Model, we developed a set of questionnaire indicators. We first identified a framework, the characteristics, with which to specify the meaning of the three nodes of the model. These characteristics are presented in the following sections.

4.2 Characteristics

We operationalised the theories and concepts discussed in Chapter 2 (Theory, Concepts and Context) to identify safety characteristics, risk management characteristics and leadership characteristics. In the following sections we present the outcomes of this operationalisation process.

4.2.1 *Safety characteristics*

In this study, *Safety* serves, alongside risk management and leadership, as one of the three core nodes of the Safety Leadership Model.

An important element of our research is exploring the effects of leaders' behaviours where it concerns the prevention of safety incidents. This implies the need to define a set of relevant indicators which determine the level of control over the primary process, and implicitly indicate the plausibility of the occurrence of safety incidents. Generally, this is called the 'safety state', which is often established by measuring/counting the number/severity of (near) incidents. But defining the safety state implies a wider view than a singular focus on incidents. We argue that establishing the safety state of an organisation requires understanding safety-related indicators from a historical, a present, and a future perspective.

Safety incidents are considered unexpected operational disturbances (unplanned deviations from planned activities), which mean that the actual occurrence of safety incidents is not something the people involved (including leaders) are able to plan or control in terms of time, place or consequences; safety incidents happen unannounced, seldom give a pre-warning, appear in a haphazard manner and lead to unpredictable effects, from near-miss incidents to disastrous effects on the fundamental values of organisations. In addition to these uncertain and uncontrollable factors, the observable consequences of materialised events are only informative about the past historical state of the primary process concerned. Regarding this restriction in awareness, Ale[1] notes:

> We cannot really assemble data on the effects before they take place and we cannot assemble data on the probability either. … When and if certain effects take place, there will be absolute certainty: the effects will have taken place. And before that there is only probability in the true Bayesian sense: a degree of belief that certain negative – or positive – effects will result from our activities. The degree of results may be increased by factual information, but it remains a belief …

Safety incident information in isolation is thus considered inadequate as a representative indicator for addressing a leader's influence on the prevention of safety incidents. In general, as the opposite of risk, there is no such thing as an objective indicator of the safety state of (the primary process of) an organisation.[2] As Slovic[3] phrased it:

> … danger is real, but risk is socially constructed. Risk assessment is inherently subjective and represents a blending of science and judgment with important psychological, social, cultural and political factors.

Within the context of this research, we therefore take the judgment (or belief) of professional, skilled and experienced people, who know their primary processes by heart and who are facing the risks of these processes on a daily basis, as the most reliable (or least unreliable) indicator of the state of an organisation's safety. For convenience, we will further refer to the state of safety simply as *safety.*

In order to obtain a comprehensive indicator of the actual safety of an organisation, we employ three different characteristics to address the leaders' effectiveness in the prevention of safety incidents. These entities are: 1) Event History, 2) Sense of Safety and 3) safety Risk Potential. We argue that the amalgamated data offers a representative picture of in historical, current and future perspectives.

Next, we will elucidate these three characteristics of the safety of an organisation.

4.2.1.1 Event History

As mentioned above, materialised events are indicators of the past. Incident reports show how an organisation has performed historically, and suggest the safety of the primary process concerned at the time the events occurred. As such this might not be indicative of its present safety, but when historical data is compared to expectations and benchmarked with organisations in relevant business sectors operating comparable primary processes, there may be an indication of whether the leaders in the organisation in

1 Ale (2009), p. 8.
2 Van Asselt (2000), p. 433.
3 Slovic (2001), p. 23.

question are more or less effective in their attempts to prevent operational disturbances than their peers in other organisations.

An inherent problem related to using incident statistics as performance indicators is that improved performance implies a reduction of information. This especially applies to major safety incidents, which, if compared with minor incidents, occur less frequently, but incident statistics are factual and hard, and therefore considered reliable indicators by many organisations and institutes.

4.2.1.2 Sense of Safety

The Sense of Safety characterises the effectiveness of a leader's influence in terms of the present safety of the primary process concerned, as envisaged by all members of the organisation. This characteristic is included in the safety construct as it relates to the conviction that people who are part of the operational aspects of a process know what to be aware of. Sometimes people in operations are accused of not being safety conscious or risk aware, but this is not always the case. People may take risks in their daily operations, but this should not be interpreted too easily as a lack of awareness.

Depending on the shared values and beliefs maintained by the members of an organisation, people are more or less enabled to cope with these trade-off challenges in a safe way. In certain organisations all identified safety risks have been eliminated or are sufficiently controlled. There is then no need to work around agreed procedures and instructions, and interrupting production to take care of suspected safety issues is seen as good practice. In other organisational cultures it is an operational reality that people feel obliged to take shortcuts and perform other substandard acts in order to achieve what they believe is expected from them. In some organisations these practices are entirely accepted and leaders (supervisory/managerial staff) even may turn a blind eye, but after an event has taken place, the same people classify these practices as unsafe acts or even violations. In addition, albeit probably with more caution, these acts continue to be practised as long as people are obliged to operate in the same environmental and organisational context, which encourages risk taking behaviour in order to achieve operational targets. It is also understood that personal factors, such as peer pressure, also may play an important role in this.

The operational realities sketched above might indicate ignorance or fatalistic orientations among people in operations, but although regularly suggested, these practices are not necessarily an indication that people are not aware of the safety risks to which they are exposed. They often know the risks better than anyone else but people in operations may have their own valid personal reasons for using different priorities than those expected by people who do not understand what it means to work in an environment in which the challenges of a primary process determine the flavour of the day. Detailed knowledge of the behavioural particularities of the primary processes and intuition developed by a sufficient dose of operational experience ensure the continuity of many risky primary processes but sometimes people in operations and their leaders misjudge the outcome of their decisions.

It is precisely this operationally-liaised population who knows which particular risks are, often latently, present. When approached in a just, non-threatening manner, their sense of operational safety is a reliable resource when assessing it.

4.2.1.3 Safety Risk Potential

The safety Risk Potential characterises the safety of operational processes with reference to the future. Different primary processes, conducted in different business sectors, imply different types of safety risks. Competent people experienced in the conduct of a particular primary process have personal as well as collective impressions of the plausibility of operational disturbances. They execute their tasks with these impressions in their minds. They are convinced about the correctness of their expectations with respect to the safety Risk Potential of the primary process, and make behavioural decisions based on these expectations. People's behaviours (leaders and followers) are thus closely related to their expected exposure to potential safety risks. This expectation is an indicator of (un-)safe behaviour by the people involved in the conduct of primary processes.

4.2.2 *Risk Management characteristics*

Risk Management is one of the three core nodes of the Safety Leadership Model in this study, alongside Safety and Leader's behaviours.

4.2.2.1 Risk Reduction Cycle

An increase in safety is operationalised in this study by reduced risks. We argue that the ultimate objective of risk management is *reducing* risks, and that risk assessment is the master key to risk reduction. The structure of the risk reduction process can be visualised as a five-phase model, the so-called *'Risk Reduction Cycle'*, which encompasses the following phases: Recognition of risks (recognition and sensemaking), Ability to intervene (opportunity, knowledge and skills), Motivation to intervene (the desire to stabilise the situation), Courage to intervene (daring to put safety first) and remedial Action (removing instability).

The rationale underpinning the cycle is that risk reduction is optimal when all phases are fully respected and accomplished. When that is the case, all controls and defences are in shape, and an organisation has achieved the highest feasible level of risk reduction.

In order to ensure the operational applicability (fit-for-purpose) of this Risk Reduction Cycle, the initial draft of the cycle was developed through an iterative, or user-centred design process. The initial design has thus been exposed to critical evaluations by various groups of safety experts in different settings (training course participants, symposium delegates, attendees of presentations, etc.) The cycle was fine-tuned on the basis of the results of these evaluations. This final Risk Reduction Cycle was considered comprehensive with respect to all aspects of the risk reduction process. The final version of the Risk Reduction Cycle is explained below.

4.2.2.1.1 *Recognition of risks*

In this first phase of the Risk Reduction Cycle the focus is on the quality and completeness of risk information. Does that information represent reality and are people aware of the threats they are exposed to? Where risk information is lacking, risk control cannot be sufficient. The result of adequate risk information is optimal awareness of risk. This risk reduction phase serves as the foundation under all initiatives to reduce risks and secure the primary process.

Analysis of this condition could have answered the question whether the potential for these safety incidents was widely known as well as the question whether the people involved were aware of the risks they were running.

4.2.2.1.2 *Ability to intervene*

Being aware of the existing risks, people must understand what to do and have the knowledge to do so.[4] Once people are aware of the risks that threaten the organisation's safety stability, they should know what to do in order to prevent a risk from escalating to an irreversible event. Depending on the organisational possibilities and individual knowledge and skills people may select one of three risk mitigating options: limiting the *severity* of identified hazards, reducing the *likelihood* of triggering an adverse event, or reducing the *exposure* of people, assets, the environment and the continuity of the organisation's primary process. By this understanding they know what action should be taken in order to reduce the identified risks to an acceptable level. Also, this includes a requirement for the presence of knowledge on site; people with the appropriate ability to intervene (conducting the required risk-reducing actions) must be available at the right time on the right place. Analysis of this condition could have answered the question whether the people involved were really sufficiently qualified and experienced.

4.2.2.1.3 *Motivation to intervene*

Once people are aware of the existence of safety risks and they know what to do to reduce these risks and have the abilities to do so, they have to be motivated to realise the required risk-reducing activities. In order to transform knowledge and understanding into action people have to be willing to do so. Legislation, Governmental Rules and Regulations as well as requirements by insurance companies or commercially important clients are strong motivators; there are no excuses for non-compliance with obligations being monitored by the parties mentioned here. The incredible decrease in fatal accidents (70% in 3 years) after the introduction of Life Saving Rules in the chemical industry and a similar effect (50% in 5 years) in hospital after increased attention by the international community, show that intrinsic motivation together with threatening reputational damage works. The key question people ask themselves here is: "What is in it for me?" Based

4 Van Kampen, Van der Beek, Steijn, Groeneweg and Guldenmund (2017).

on the answer to this question the questioner will be motivated to act or not to act.

4.2.2.1.4 *Courage to intervene*

After someone has decided that intervening is the right thing to do, he will select what action to take. In this crucial phase he also decides whether he is the right person to take the trouble to mitigate the identified risk, or deny that the risk is a threat to the safe conduct of the organisation's primary process and leave the mitigating action to others. Here the concept of moral courage (ref. 2.2.7.4) is an essential behavioural property.

In cases where people have the courage to intervene, safety is the most important thing for them, and other priorities are possibly compromised. In that case, there is an opportunity to mitigate the identified risk, however, the actual effect of this 'courageous' decision still depends on how this intervention is followed-up.

4.2.2.1.5 *Remedial Action*

The output of the 'Courage to Intervene' phase results in either *intervention* (potentially leading to mitigation of the identified risk), represented in Figure 22 by the lower return line (leading to the 'Action' phase) or *no intervention*, represented by the upper dotted return line (leading to 'persisting instability' and leaving the risk as is). As long as nobody has decided that safety is most important, the risk remains and the potential of a safety incident also remains.

The Risk Reduction Cycle as described above can be graphically visualised, as shown below.

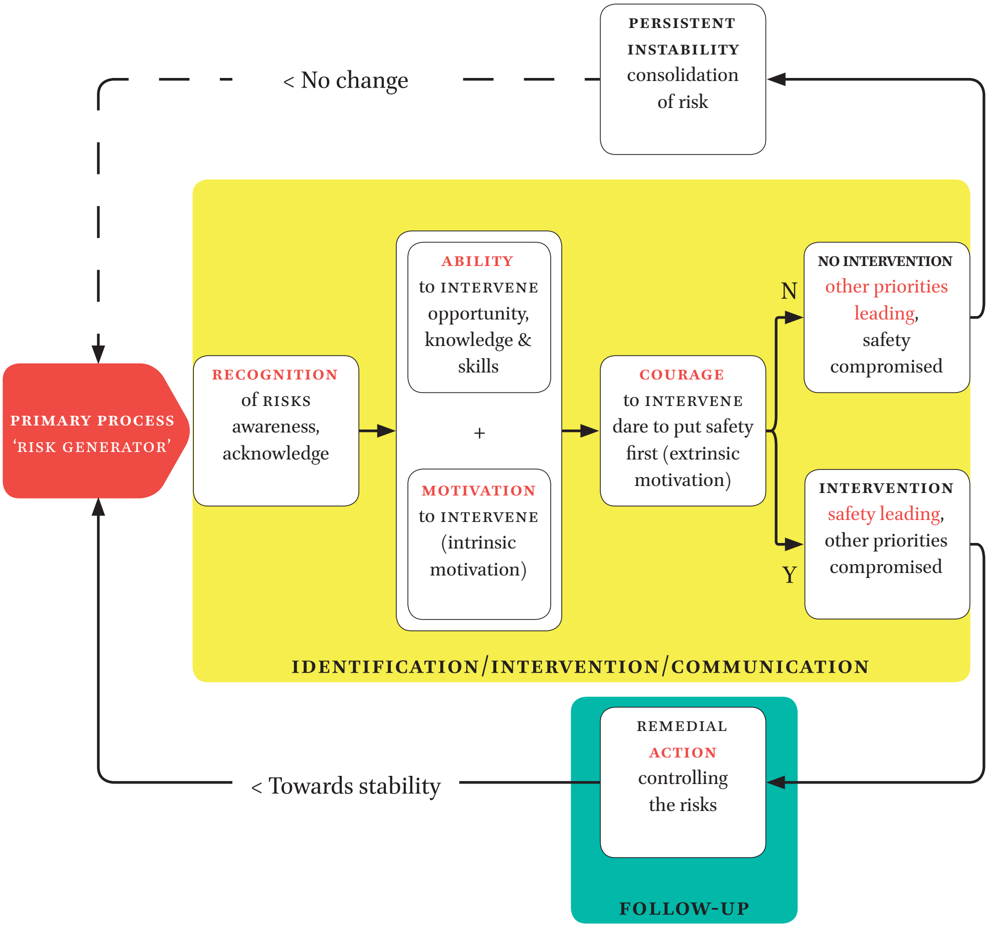


FIGURE 22 Risk Reduction Cycle

In Figure 22 the five phases of the Risk Reduction Cycle are embedded in a circular model.

4.2.3 *Leadership characteristics*

In this study, Leadership serves, in addition to Safety and Risk Management, as one of the three core nodes of the Safety Leadership Model.

The way leadership is practised, is often explained by mentioning a leadership *style.* Leadership styles describe the conceptual principles of leadership according to certain leadership theories. On a more fundamental level, three underlying behavioural dimensions of leadership, so-called 'human motives' are identified; achievement, affiliation and power. These dimensions refer to different motivational strategies by leaders in relation to their subordinates. In this research, these strategies are referred to as three 'leadership orientations'; Task, Relation and Self orientation. These orientations contain elements of different leadership styles, but overlap these styles and transcend their boundaries.

4.2.3.1 Task-oriented leaders

The main aim of Task-oriented leaders is to achieve production targets. Task-oriented leaders set challenging goals and expect to reach the highest performance. They monitor their team members closely to ensure the continuation of the primary production process. They are optimistic, and trust their intuition when questioning which decision to make. Task-oriented leaders believe that focus on procedures leads to better results, but at the same time they "have guts"; they do not consult with others, but do what they deem right, even if procedures prescribe otherwise.

4.2.3.2 Relation-oriented leaders

Relation-oriented leaders are friendly people. They show compassion and are attentive vis-à-vis their team members. The display social and enthusiastic behaviour. Relation-oriented leaders are good listeners and take the time to communicate. They are honest, sincere and incorruptible. Team members who work for Relation-oriented leaders are rewarded for their efforts.

4.2.3.3 Self-oriented leaders

Self-oriented leaders are dominant people. They behave in an individualistic way and avoid involvement with their team members. Self-oriented leaders have an authoritarian way of communicating, and always have the final word. They claim credit for work done by others, and sometimes behave in a hostile way. Self-oriented leaders need to be monitored regarding taking unacceptable safety risks.

4.3 Safety Leadership Model Version II

We presented Safety Leadership Model Version I in Section 4.1. In the previous sections we added characteristics to the three nodes of this model. In this section we will enhance the Safety Leadership Model Version I to a Version II model by including these characteristics. As a consequence of including the characteristics, we will retitle the nodes: 'Risk Management' to *Risk Reduction Capacity* and 'Leaders' Behaviours' to *Safety Leadership*. We explain these changes below.

4.3.1 *From Risk Management to Risk Reduction Capacity*

In the context of this research, the level of risk reduction is determined by investigating the perceptions of the online proactive survey respondents regarding the five phases of the Risk Reduction Cycle: Recognition, Ability, Motivation, Courage and Action (Figure 22).

In Version II of the Safety Leadership Model, we refer to the aggregated scores of these perceptions as the *Risk Reduction Capacity*. Finally, we propose that the level of Risk Reduction Capacity is an indicator of the opportunity for safety incidents to occur, where a low level of Risk Reduction Capacity relates to a high opportunity of occurrence, and vice versa.

4.3.2 *From Leaders' Behaviours to Safety Leadership*

Where people in the same organisation operate as a group to achieve shared goals, they do not act as independent individuals, but they co-operate in order to complete the tasks which their leaders consider as required to achieve the organisation's goal. Each member of the group possesses individual competences matching the requirements and responsibilities of their specific assigned tasks. In conjunction with the specific circumstances as occurring in their day-to-day work, the different tasks are divided among the members of the group and relate to the specific knowledge, skills and other relevant properties of the individual members.[5] Operational tasks are associated directly with the production of intended added values (i.e., products or services); altogether these tasks represent the primary process (ref. 2.4.1.3).

The Leaders' Behaviours node in the Safety Leadership Model includes the way leaders behave when dealing with the prevention of operational disturbances. We distinguished three characteristics of leaders' behaviours as orientations; Task, Relation and Self orientations (ref. 4.2.3). In Version II of our Safety Leadership Model, we refer to these characteristics as *Safety Leadership*, which we define as *all activities that leaders conduct with the objective of preventing operational disturbances, which may* (*potentially*) *result in a safety incident*.

4.3.3 *Safety Leadership Model Version II*

As explained above, we included the three leadership orientations (Task, Relation- and Self-orientation), as well as the five risk reduction phases (Recognition, Ability, Motivation, Courage and Action) and the three safety characteristics (Event History, Sense of Safety and Risk Potential). We also retitled two of the three nodes. These modifications resulted in Version II of the Safety Leadership Model, which is shown in Figure 23 below.

5 Kotter (1999).

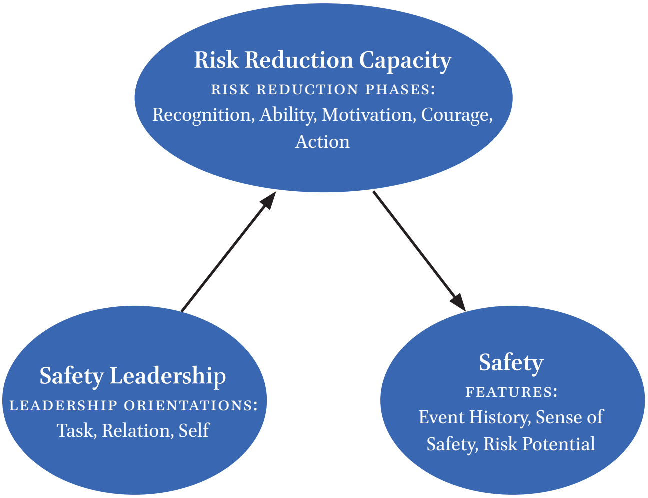


FIGURE 23 Safety Leadership Model Version II

We developed an online prospective survey questionnaire based on the Safety Leadership Model Version II. In order to test this questionnaire in terms of validity and reliability, as well as to obtain an indication of the relevance of the questionnaire indicators and its practical applicability for the target population, we conducted a pilot survey among a limited group of relevant people. The next chapter describes the design, conduct and outcome of this pilot survey.

The essence of leadership is to get others to do something because they think you want it done and because they know it is worth while doing.

DWIGHT EISENHOWER

5 Prospective study (pilot survey)

Prior to conducting an online prospective survey among all anticipated business sectors, we decided to test the robustness of the Safety Leadership Model and verify the validity and reliability of the designed survey questionnaire by conducting a pilot survey. We also used this pilot to obtain an indication of its relevance and practical applicability for the target population. We distributed the final draft of the questionnaire among a group of experts in the field of operational safety. Reviewing the survey responses as generated by the pilot population enabled us to review the appropriateness of the questionnaire questions and to analyse the reliability and validity of the questionnaire. These responses showed some promising results concerning the relationship between safety leadership and risk reduction. The following sections describe the design, conduct and results of this pilot survey.

5.1 Pilot survey (design)

We included five statements in the questionnaire relating to the five phases of Risk Reduction Capacity (Recognition, Ability, Motivation, Courage and Action). We developed a set of 35 indicators to represent the particular leaders' behaviours in relation to the three leadership orientations (Task, Relation and Self) as described in Section 2.3.6 'Profiling leaders'.

We also took the opportunity during the design of this questionnaire to include seven *leadership typologies*, which we considered sub-categories of the three leadership orientations, and to describe more specifically the meaning of leadership orientations. These leadership typologies are described as follows. Vis-à-vis their followers, Task-oriented leaders typically behave as *motivators, achievers*, or as a *knowledge base*. Relation-oriented leaders are typically *team players,* or *stimulators*, and Self-oriented leaders exhibit behaviours which are typical of *rulers* or *individualists*. During the design process of the draft survey questionnaire, we assigned all leadership indicators included in the questionnaire to one of these leadership typologies. Compared with the relatively conceptually-phrased behavioural orientations (Task, Relation and Self), we expected these more specific leadership typologies to better communicate the meaning of specific behavioural orientations. To prevent the respondents being influenced/biased, these relationships (questions/behavioural orientations/leadership typologies) were not visible on the questionnaires distributed to the respondents. The layout of the pilot survey questionnaire is shown in Appendix 15.3: Questionnaire Used in Pilot Survey.

The draft questionnaire underwent various iterations during the design phase, mainly as a result of feedback from the different safety experts and scientific researchers consulted, who kindly shared their views and experiences with us. In order to improve the representativeness and validity of the survey's indicators, these 'first level testers' also advised us about how to improve the different draft versions of the questionnaire. After this first level test, the final draft of the questionnaire was considered ready for use, and the online pilot survey was initiated.

5.2 Pilot survey (conduct)

The online pilot survey was conducted among safety experts who work in the Dutch business sectors relevant to this research. We approached 150 safety professionals for the pilot survey, mainly members of the Dutch Society of Safety Practitioners (NVVK). The respondents are all recognised as experts in the field of risk management and safety. We asked these people to complete the questions on our final draft online survey questionnaire and provide us with feedback about their experience of the activity.

The survey questionnaire invited the respondents to report their individual perceptions regarding the behaviours of their direct leaders. The respondents were also asked to describe their perceptions of Risk Reduction Capacity as applicable to their own working environment. The responses to the pilot survey confirmed that our draft questionnaire indeed produced reliable and useful data regarding the relationship between Safety Leadership orientations (Task, Relation and Self) and Risk Reduction Capacity (Recognition, Ability, Motivation, Courage and Action). We also received positive feedback about the applicability and relevance of the design of the online questionnaire.

We next present the demography of the response group, and describe the way the data acquisition for the online pilot survey.

5.2.1 *Demography*

We asked 150 professionals to participate in an online pilot survey. A total of 99 questionnaires were returned, of which 88 responses were sufficiently completed and thus usable for analysis. All participating professionals were employed by organisations operating in one of the business sectors relevant to this research. The valid participating respondents held five different hierarchical position levels: directors/board members, managers, supervisors, support staff and operational employees. Within this group of safety experts 55% of the respondents indicated belonging to the support staff category and 36% indicated belonging to the manager category. These positions are considered representative of professional safety advisors in the target business sectors. The remaining 9% of the respondents reported belonging to the director, supervisor, or operational employee categories.

The responses as returned by this group revealed that 82% of their direct supervisors were men and 18% women.

5.2.2 *Data acquisition*

The data was collected using the Qualtrix XM online survey tool under licence of Leiden University. The respondents scored each statement in the questionnaire on a 7-point Likert scale from strongly disagree, to disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree and strongly agree. In the Qualtrix data collecting programme these terms corresponded with a numerical scale ranging from -3 to +3. A 'don't know'-option was also included. For optimal understanding we decided to use wording instead of a numerical scale.

5.3 Pilot survey (results)

Among other, mainly demographic, information, this pilot survey revealed data related to Safety Leadership and to Risk Reduction Capacity. The acquired data served as an essential information source to assess the quality of the draft survey questionnaire in terms of its validity, reliability, relevance and practical applicability to test the Safety Leadership Model, and thus to reliably answer the principal research query: "Can leaders of organisations help to prevent safety incidents?" We therefore analysed the survey data generated by safety experts regarding: a) mean scores of Safety Leadership orientations, b) mean scores of Risk Reduction Capacity, c) the correlation between the three Safety Leadership orientations and the five phases or the Risk Reduction Cycle, and d) the construct validity of the survey questionnaire.

In the following sections we present the outcome of these testing phases.[1]

We first present the mean scores as acquired by this survey from the general employees.

5.3.1 *Mean scores in pilot survey*

We analysed the acquired survey data in order to establish the different mean scores for Safety Leadership orientations in general and for each business sector. We then present the results of that analysis.

1 Out of respect for individual anonymity, data recognisably generated by groups consisting of fewer than four people is not included.

5.3.1.1 Safety Leadership in pilot survey

The Safety Leadership-related behavioural orientations of leaders were established by collecting the respondents' individual judgements on three statements concerning the behavioural orientations (Task, Relation and Self-) of their direct supervisor. The leadership orientations (Task, Relation and Self-) are represented by the mean scores for the 35 Safety Leadership-related indicators as included in the survey questionnaire. We then present these general mean scores, as well as the mean scores for each business sector.

General Safety Leadership orientations

This section presents the leadership orientations of the respondents' direct supervisors in all organisations.

	Task	Relation	Self
Mean	0.7742	0.8202	-0.5909

BAR CHART 1 **General Safety Leadership Profile (pilot survey)**

The mean scores as generated by the respondents, shown in Bar Chart 1 above, represent the perceptions that safety experts have regarding the preferred leadership orientations (Safety Leadership) of their direct supervisors. The scores show that, on average, they *somewhat agree* that their direct supervisors show Task- and Relation-oriented behaviours, where Relation orientation (M=0.82, SD=0.99), slightly prevails over Task orientation (M=0.77, SD=0.71). The respondents also report that, on average, they *close to somewhat disagree* that their direct supervisors show Self-oriented behaviours (M=-0.59, SD=1.10).

Safety Leadership orientations per business sector

This section explains the leadership orientations of all respondents' direct supervisors, distinguished per business sector are explained.

	Tank storage (n=14)	Hospitals (n=18)	Process industry (n=11)	Oil & gas (n=10)	Rail infra n=10)	Other (n=23)
Task	0.8000	0.8370	0.4788	0.8667	1.1333	0.6348
Relation	0.8961	0.8788	0.6860	0.7091	1.2182	0.6443
Self	-0.7857	-0.5278	-0.3182	-0.2750	-1.2750	-0.5217

BAR CHART 2 Safety Leadership per business sector (pilot survey)

Bar Chart 2 presents the mean scores for each business sector. Here we see some interesting differences between six business sectors. At first the safety experts in the tank storage sector show a relatively low, *close to somewhat disagree* score for Self-oriented leadership behaviour (M=-0.79, SD=1.00). In the process industry leaders are more Relation-oriented than Task-oriented, and in the oil and gas sector the reverse is the case. The oil and gas sector reports a relatively high score for Self-oriented leadership behaviour (M=-0.28, SD=1.2). The rail infrastructure population stand outs by having relatively high scores for Task-oriented (M=1.33, SD=0.59) and Relation-oriented (M=1.21, SD=1.08) leadership behaviours, and it has a relatively low score for Self-oriented leadership behaviour (M=-1.28, SD=1.11).[2]

Apart from the above respondents' individual judgements about the statements concerning the behavioural orientations (Task, Relation and Self-) of their direct supervisors, we collected their statements regarding capacities for risk reduction in their organisations. The next section shows the data collected in this part of the pilot survey.

2 The scores from the sector General Infrastructure are not shown due to lack of respondents (n=2)

5.3.1.2 Risk Reduction Capacity in pilot survey

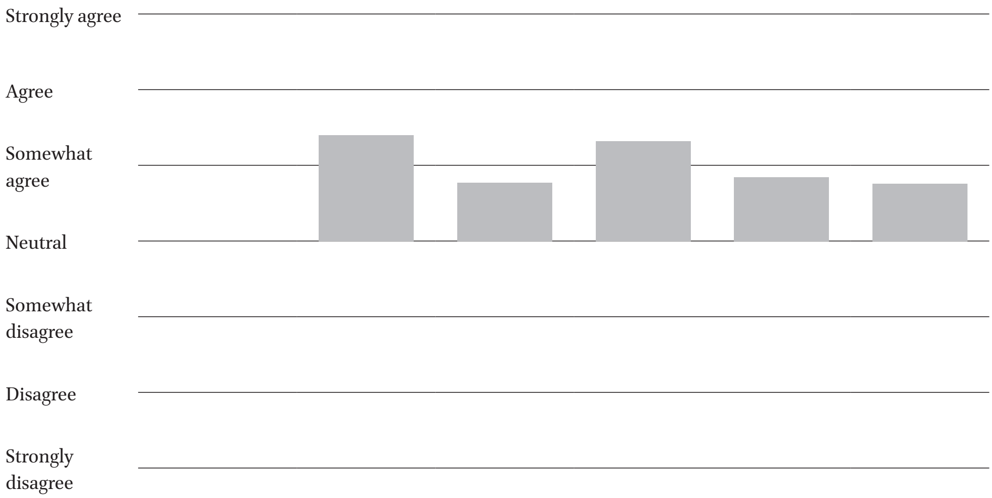
The Risk Reduction Capacity of an organisation is represented by the mean scores for the five risk reduction phases (Recognition, Ability, Motivation, Courage and Action).

The Risk Reduction Capacities as perceived by the safety experts were established by collecting the respondents' individual (dis-)agreement concerning the effectiveness of the five individual phases of the Risk Reduction Cycle.[3]

We resent the results of that analysis via the different mean scores for Risk Reduction Capacity in general, for each business sector and according to the gender of the supervisors.

General Risk Reduction Capacity

In this section the overall Risk Reduction Capacity of all organisations is presented.



	Recognition	Ability	Motivation	Courage	Action
Total pilot group	1.4	0.77	1.32	0.84	0.76

BAR CHART 3 General Risk Reduction Capacity (pilot survey)

The perceptions of the safety experts, as graphically presented in Bar Chart 3 above, show that people at the work floor level recognise the safety risks in their working environment, to an average degree, scoring between the levels *somewhat agree* and *agree* (*M*=1.44, *SD*=1.12). To a lesser extent, the respondents *somewhat agreed* that people at work floor level had the ability to intervene when risks are recognised (*M*=0.77, *SD*=1.2). Motivation had similar scores to recognition, between *somewhat agree* and *agree* (*M*=1.32, *SD*=1.21).

3 Since the safety experts, members of the safety experts are divided over different organisations, it is to be understood that the scores generated by the safety experts are for the purpose of testing the quality of the questionnaire only and do not reflect the real situation in a particular organisation.

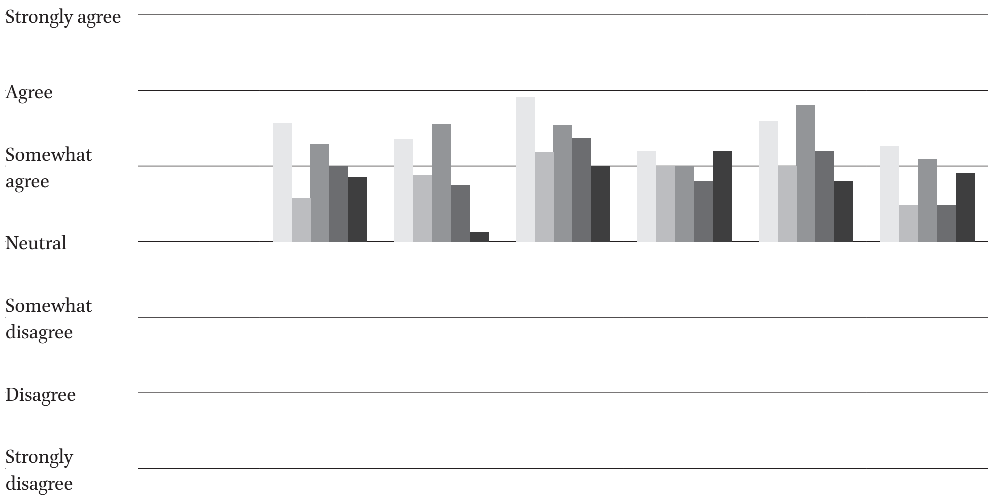
Courage scored a little lower than *somewhat agree* (*M*=0.83, *SD*=1.34). Timely Action to solve safety risks scored lowest, between *somewhat agree* and *neutral* (*M*=0.76, *SD*=1.46). The statistical results of this investigation are presented in Table 2 below.

	Recognition	**Ability**	**Motivation**	**Courage**	**Action**
Valid	87	86	88	86	85
Missing	1	2	0	2	3
Mean	1.4368	0.7674	1.3182	0.8372	0.7647
Std. deviation	1.11753	1.20464	1.20864	1.34480	1.46098

TABLE 2 Risk Reduction Capacity (pilot survey)

Risk Reduction Capacity per business sector

This section presents the risk reduction capacities of all organisations, distinguished per business sector.



	Tank storage (n=14)	Hospitals (n=18)	Process industry (n=11)	Oil & gas (n=10)	Rail infra (n=10)	Other (n=23)
Recognition	1.5714	1.3529	1.9091	1.2000	1.6000	1.2609
Ability	0.5714	0.8824	1.1818	1.0000	1.0000	0.4783
Motivation	1.2857	1.5556	1.5455	1.0000	1.8000	1.0870
Courage	1.0000	0.7500	1.3636	0.8000	1.2000	0.4783
Action	0.8571	0.1250	1.0000	1.2000	0.8000	0.9091

BAR CHART 4 Risk Reduction Capacity per business sector (pilot survey)

Due to the different nature of the various business sectors in this research, the mean scores for the respective risk reduction phases are also different for these sectors, however, as can be seen in Bar Chart 4 above, there are also similarities.[4]

We first note that the respondents in the tank storage, hospital, process industry, and rail infrastructure sectors, as well as the respondents working in non-specified sectors (combined in the 'other' group), consider Recognition and Motivation as the two highest scoring risk reduction phases in their respective sectors.

The respondents working in the hospital, process industry, and rail infrastructure sectors, and the 'other' group, consider Action as the lowest scoring risk reduction phase. The relatively high scores overall from the respondents in the process industry are of interest, with Recognition (M=1.91, SD=1.38) the highest scoring risk reduction phase in all sectors. The relatively low score for Ability in the tank storage sector (M=0.57, SD=1.4) shows that the respondents perceive that workers have limited opportunity, knowledge and skills to intervene when risks are recognised. The response for the Action risk reduction phase in the hospitals sector is worrying (M=0.13, SD=1.26), which scores lowest of all risk reduction phases in all sectors. The relatively high score for Action (M=1.2, SD=1.48) in the oil and gas sector shows that recognised risks are remedied more effectively than in other sectors. The fact that the respondents/employees are employed in remote locations with limited options to escape, and are thus potentially vulnerable victims, may play a role.

We next present the correlation analysis of the survey data acquired in this pilot survey.

5.3.2 *Correlating Safety Leadership and Risk Reduction Capacity in pilot survey*

We correlated the mean scores of the three leaders' behavioural orientations (Task, Relation and Self-) with the mean scores of the five risk reduction phases (Recognition, Ability, Motivation, Courage and Action) as obtained in a pilot survey among a group of 88 safety experts.[5]

The results of this analysis are provided in Table 3 below.

4 The scores from the General Infrastructure sector are not shown due to the lack of respondents (n=2).

5 Applied SPSS v.25 analysis: Bivariate correlation (Spearman Rank).

Safety Leadership correlation matrix (Safety experts N=88)					
	Recognition	**Ability**	**Motivation**	**Courage**	**Action**
Task	.248*	.317**	0.202	.351**	0.169
Relation	.270*	.250*	.363**	.354**	0.155
Self	-0.171	-0.121	-.363**	-0.191	-0.126

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

TABLE 3 Safety Leadership correlation matrix safety experts

5.3.2.1 Classification of identified values

In order to evaluate the statistical power of the identified correlation levels, we refer to a hierarchical taxonomy of variables to produce empirical effect size benchmarks, as developed by Bosco et al.[6] Their Correlational Effect Size Benchmarks table (Appendix 15.4) refers to statistical power criteria as published by Cohen[7] in terms of uncorrected effect size (|r|). The criteria as published by Bosco et al. conclude that |r| values between .24 and .50 are classified as a 'medium' or 'moderate' effect size. We used this effect size classification as guidance during the interpretation of the correlations as described below.

5.3.2.2 Observations and interpretation of identified correlations

When evaluating the identified correlations, we applied the effect size criteria as described in the previous paragraph. This evaluation led to the following results:

Task-oriented leadership behaviours correlate significantly, and with moderate effect size, with the risk reduction phases Recognition (ρ=.248**), Ability (ρ=.317**) and Courage (ρ=.351**). Task-oriented leadership behaviours do not correlate meaningfully with the risk reduction phases Motivation and Action. Relation-oriented leadership behaviours correlate significantly, and with moderate effect size, with the risk reduction phases Recognition (ρ=.270*), Ability (ρ=.250*), Motivation (ρ=.363**) and Courage (ρ=.354**). Relation-oriented leadership behaviours do not correlate meaningfully with the Action risk reduction phase.

Self-oriented leadership behaviours correlate significantly *negatively*, and with moderate effect size, with the Motivation risk reduction phase (ρ=-.363**). Self-oriented leadership behaviours do not correlate meaningfully with the risk reduction phases Recognition, Ability, Courage and Action.

6 Bosco, Aguinis, Singh, Field and Pierce (2015), p. 433.
7 Cohen (2013).

Based on the above observations, there is support for the assumption that different types of leader behaviours engage different aspects of Risk Reduction Capacity. More specifically: Task- and Relation-oriented leaders appear to relate to the Risk Reduction Capacity of organisations in a positive way. Conversely, Self-oriented leaders seem to relate to Risk Reduction Capacity in a negative way.

5.3.3 *Construct validity of draft survey questionnaire*

After analysing the data generated by this pilot survey, the construct validity of the draft online survey questionnaire design was assessed by determining the construct validity (Cronbach's α) for the three constructs that comprise the variable *Safety Leadership orientations* (Task, Relation and Self-). The responses returned in this pilot survey demonstrated the following construct validities for the survey questionnaire: Task (α=.848), Relation (α=.921) and self (α=.862).

Based on the values reported by this pilot survey, we hold that the construct validity of the survey questionnaire suggests sufficient robustness for its use obtaining valid data regarding the different Safety Leadership orientations.

5.4 Improving survey questionnaire design

In addition to acquiring survey data, the pilot survey described in the previous sections also served to test the robustness and representativity of the Safety Leadership Model and the applicability of the draft survey questionnaire. The experiences gained by evaluating the pilot survey showed some room for improvement with respect to the questionnaire design. These improvements involved the removal of one superfluous Safety Leadership indicator statement, and the inclusion of three safety indicators. The design improvements are explained below.

Removal of superfluous leadership indicator

The draft survey questionnaire consisted of 35 statements related to Safety Leadership orientation; all of which had been categorised into three Safety Leadership orientations. We noticed from the data in this pilot survey, however, that one statement did not fit any of the Safety Leadership orientation constructs. This was: 'My supervisor sometimes deliberately turns a blind eye and is flexible where compliance with rules and procedures is concerned.' We therefore removed that particular statement from the questionnaire, which resulted in a total of 34 statements related to Safety Leadership orientations.

Inclusion of safety indicators

The safety of the organisation was not investigated via the pilot survey for safety-experts, because the need to add safety (the third node of the Safety Leadership Model Version II, (ref. Figure 23) to the survey questionnaire had not been identified before the evaluation of the pilot survey. 'Safety' was thus added *after* the pilot survey had been conducted. We solved this by updating the design of the questionnaire by adding three indicators related to safety, in order to elicit the respondents' views about safety in their organisations from historical, present and future perspectives. We added three statements addressing: a) safety incidents experienced, b) their present level of confidence in the safety of their organisations, and c) their perceptions of the potential risk level of their organisations.

5.5 Pilot survey conclusions

We conducted a pilot survey in which 88 safety experts were recognised as valid respondents to establish the quality of the draft survey questionnaire.

Based on the results of this pilot survey, we argue that there is support for the assumption that different types of leader behaviours engage different aspects of Risk Reduction Capacity. More specifically: Task- and Relation-oriented leaders appear to relate to the Risk Reduction Capacity of organisations in a positive way. Conversely, Self-oriented leaders seem to relate to Risk Reduction Capacity in a negative way.

An analysis of the data from this pilot survey shows that the construct validity of this questionnaire is sufficient to produce reliable data concerning the Task, Relation and Self-Safety Leadership orientations.

Based on the above analysis of survey data collected via the draft survey questionnaire, we argue that applying a questionnaire via an online survey is an appropriate means with which to solve the principal research query. We did identify some room for improvement in the design of this particular questionnaire during evaluation of this pilot survey exercise. After implementing the above improvements, we declared the survey questionnaire final, and 'fit for purpose' in extended research in which an online prospective survey among a wider population was foreseen.

This extended prospective research will be explained further in the next chapter.

What has happened, we take seriously, what could have happened, we ignore.

NICOLAS TALEB

6 Extended prospective research

Using the pilot survey described in the previous chapter, we investigated the relationship between the characteristics of Safety Leadership and Risk Reduction Capacity as perceived by a group of safety experts. We evaluated the draft questionnaire according to the findings of this pilot survey, and developed an improved version. In order to verify the representativity of the data provided in the pilot survey we extended our research by conducting an online prospective survey among a wider group of respondents: 4561 general employees working in 33 different organisations, operating in six different specific business sectors. After the survey data had been collected and analysed, interviews were held with CEOs, operational managers and safety managers, to collect their thoughts on the data.

This chapter contains information about the online prospective survey, as well as about the reflection process. In the following sections we discuss the design, organisation, conduct and results of the online prospective survey.

6.1 Survey design

General

In addition to some demographic questions, the survey questionnaire contained statements in order to identify the relationship between the three core constructs of the Safety Leadership Model Version II (Safety Leadership, Risk Reduction Capacity and Safety) used to find an answer to the principal research query: 'Can leaders of organisations help to prevent safety incidents?'

We used the survey questionnaire version including the improvements described in Section 5.4.

The questionnaire invited the respondents to score their (dis-)agreement with 42 statements; 34 statements relating to Safety Leadership, five statements relating to Risk Reduction Capacity and three statements relating to safety. Next, we explain the structure of these statements:

Statements related to Safety Leadership

The target population was invited to indicate their personal perceptions of the way their direct leaders behave. In order to receive a structured picture of these perceptions, the population was presented with a set of 34 indicators regarding individual behavioural orientations. These statements relate to specific Task-, Relation- and Self-oriented behaviours, which are considered indicative of the construct, referred to as the leaders' behavioural orientations (ref. 2.3.6).

The 34 statements (see Appendix 15.5) were thus categorised into the following labels:
- 13 statements indicative of Task-oriented behaviours;
- 13 statements indicative of Relation-oriented behaviours;
- 8 statements indicative of Self-oriented behaviours.

Statements related to Risk Reduction Capacity

- In the workplace, people are aware of the local safety risks;
- In the workplace, people are able to solve those safety risks;
- In the workplace, people are motivated to solve safety risks;
- On the work floor, people dare to intervene themselves to solve safety risks;
- Known safety risks are resolved in a timely manner.

Statements related to Safety

Safety was measured by collecting the respondents' individual (dis-)agreement regarding statements concerning three indicators representing their views on historical (events history), present (Sense of Safety) and future safety-related (Risk Potential) conditions.

The following statements are included in the questionnaire:
- Event History: 'A great deal has gone wrong in the field of safety within my organisation in the past year';
- Sense of Safety: 'I feel safe in my organisation';
- Risk Potential: 'There is a real risk of accidents in my organisation'.

Moderator variables

The design of the survey questionnaire allowed the mean scores to be analysed, distinguished by the following moderator variables: general, business sectors, gender of supervisors, hierarchical positions, age, vocational experience, accident-related history.

A copy of the survey questionnaire is presented as Appendix 15.5.

6.2 Survey Organisation

6.2.1 *Survey reference*

Safety Leadership Model Version II (ref. Figure 23) served as a reference in this online prospective survey.

6.2.2 *Selection criteria*

Selection criteria for participating business sectors

The six business sectors were selected on the basis of:

- The diversity of their primary processes;
- The vulnerability of these processes to major incidents (fatality, permanent disability, major economic effect, major environmental effect).

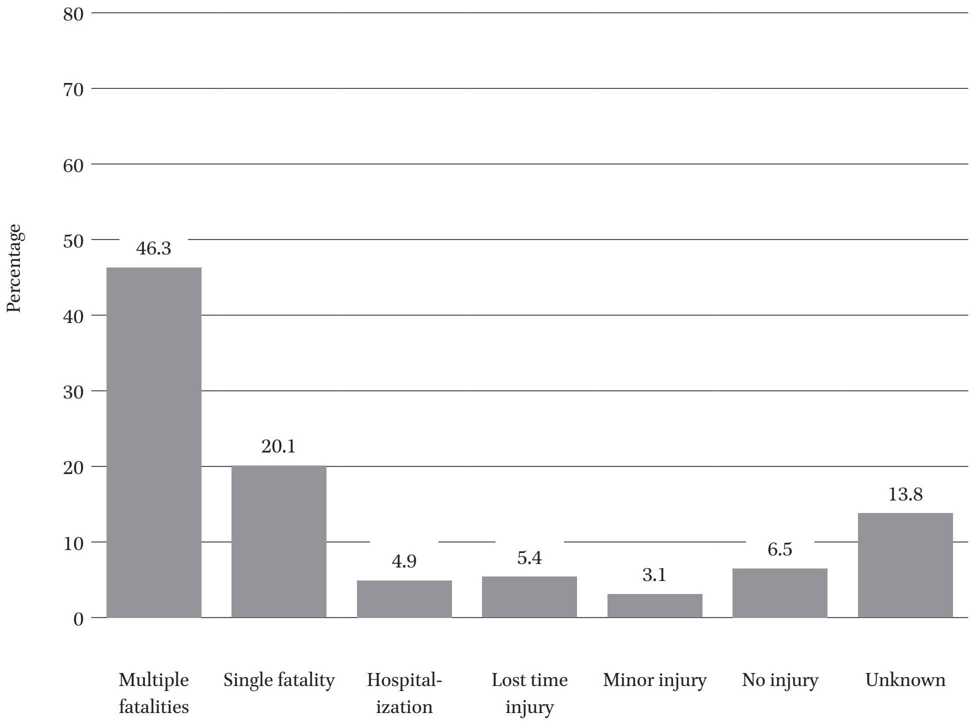
Selection criteria for participating organisations

This research includes the tank storage, hospital, process industry, oil and gas exploration and production, general infrastructure, rail infrastructure and other industries as business sectors. These business sectors are considered 'high-risk' in the context of safety incidents. All participating organisations are based in the Netherlands.

Organisations in each of the six business sectors were asked to participate in this study. They were selected if:

- The organisation operates in one of the selected business sectors;
- Management supported participation in this study;
- The researcher had access to key people; and
- Their primary processes had a high potential for safety incidents for example fatalities, permanent disability, major economic effect, or major environmental effect.

The participating organisations were selected based on the presumption that they were vulnerable to safety incidents because they execute primary processes where high safety risks are present. We asked all respondents to indicate the type of safety incidents (in terms of severity) they considered possible in their organisations. Bar Chart 5 below shows the percentages of respondents, and their responses regarding the potential of possible safety incidents.



BAR CHART 5 Potential severity of incidents

The presumption that these organisations are vulnerable for safety incidents was confirmed as 66.4% of the respondents replied that an operational disturbance in their organisations could result in a (multiple) fatal incident or (major) damage to assets, pollution of the environment, or damage to the organisations' reputation. Also, 4.9% of the respondents indicated that their organisations run the risk of incidents requiring the hospitalisation of victims. This question was answered by 75.8% of the valid survey population.

These percentages confirmed the relevance of conducting this research in the selected business sectors.

6.2.3 *Demography*

Respondents

The participants of this online prospective survey totalled 4561 respondents, labelled 'general employees' and working in six different specific business sectors.

For the purpose of analysis, the original data collected was exported using the online data collection tool Qualtrix XP to SPSS (v. 25), and then sanitised as described below.

Of these 4561 people, 141 respondents did not give consent to use their responses for scientific research. Another 344 respondents did not complete the questions related to risk reduction. After these 485 respondents were removed from the database (Sanitation 1) 4076 valid respondents were left. Of this group, 508 people completed less than 70% of the Safety Leadership related questions.[1] These respondents were removed from the database (Sanitation 2). The data base still comprised 3568 respondents. Of this subtotal, 61 respondents answered three or more of five questions related to risk reduction with 'Don't know.' After this (Sanitation 3) process, 3506 valid respondents populated the data file.

The scores of 29 respondents showed no spread (SD 0). These respondents were eliminated and another 58 respondents were taken out as the spread of their data exceeded the limit of two standard deviations (Sanitation 4). After eliminating these 87 respondents from the database, a complement of 3420 valid respondents were left included in the analysis of this prospective survey. After these sanitation operations, the database was split into two separate data files: one for data obtained from safety experts (88 valid respondents), and one for data obtained from general employees (3332 valid respondents).

Direct supervisors of respondents

The valid respondents in this research also reported the hierarchical position of their respective direct supervisors. Out of a total population of 3332, 3326 respondents answered this questionnaire question. This investigation found that 12% of the general employees were directly supervised by directors or board members, 25% by managers and 29% supervisors, and 34% were supervised by senior staff (the latter category refers to hospital employees only). The details of this investigation are given in Table 4 below.

	Frequency	%
Director/Board	401	12.0
Manager	818	24.5
Supervisor	973	29.2
Senior staff	1134	34.0
Subtotal	3326	99.8
Missing	6	0.2
Total	3332	100.0

TABLE 4 Hierarchical positions of respondents' direct supervisors

1 A 70% response was considered the cut-off point for a representative response rate.

6.3 Survey conduct

We used personal communication (email and telephone) to ask the management of the participating organisations to encourage their employees to participate in this survey. The general employees/potential respondents were asked to participate in this survey by their individual leaders.

The survey questionnaire could be accessed via an internet link and included an option to answer the survey questions using a smart phone. We had no access to the identity of the respondents.

Most of the data was collected using the Qualtrix XM online survey tool under licence of Leiden University.[2] The respondents scored each statement in the questionnaire on a seven-point Likert scale from strongly disagree, to disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree and strongly agree. These terms corresponded in the Qualtrix data collecting programme with a numerical scale ranging from -3 to +3. A 'don't know' option was included. We decided to use wording (from strongly disagree to strongly agree) instead of the numerical scale for optimal understanding.

The average response time for this survey was expected to be around 15 minutes (as indicated by the Qualtrix data collection software).

The data acquisition period was from March 2016 until October 2019.

6.4 Survey results (primary analysis)

In order to determine the answer to our principal research query, 'can the leaders of organisations help to prevent safety incidents?' we analysed the data acquired through the online prospective survey. We analysed the mean scores for each node on the Safety Leadership Model. This analysis focused on general results according to all respondents, and also the results distinguished per business sector.

We performed two different types of statistical analysis on the acquired data related to the three nodes of the Safety Leadership Model: a) a Spearman's Rank correlation analysis, and b) a linear regression analysis. These analyses were performed on data generated by 3332 respondents.

Finally, in order to obtain an impression of the representativity of the survey results, we asked a selection of senior leaders in the surveyed organisations to reflect on the survey results as applicable to their organisations. We present the results of these primary analyses below.[3]

2 Most of the survey questionnaires were distributed using an online data collection tool (Qualtrix). According to the request of one participating organisation, the questionnaires were distributed to the respondents as paper copies ('hard copies').

3 Out of respect for individual anonymity, data recognisably generated by groups that consisted of fewer than four people is not presented.

6.4.1 *Mean scores*

We analysed the acquired survey data for the constructs of Safety Leadership Orientations, Risk Reduction Capacity and Safety in order to establish the different mean scores of the nodes on the Safety Leadership Model.[4]

The employees of 33 organisations operating in six different specific business sectors responded to the online prospective survey questionnaire. Due to the differences in staffing between the participating organisations, the distribution of the respondents is not identical over the business sectors. The contributions of general employees from the rail infrastructure sector (n=1010) and the hospital sector (n=767) are relatively large, but fewer employees from the process industry (n=128) and the tank storage sector (n=185) participated. The number of responses from the oil and gas industry (n=414) and the general infrastructure sector (n=454) were in between the other categories. The category 'other' represents respondents who participated as attendees of symposia, courses and workshops, and whose business sectors are not known. An overview of the distribution of respondents is presented in Table 5 below.

	Frequency	%
Tank Storage	185	5.6
Hospitals	767	23.0
Process Industry	128	3.8
Oil & Gas	414	12.4
Infra General	454	13.6
Rail Infra	1010	30.3
Other	374	11.2
Total	3332	100.0

TABLE 5 Distribution of respondents over business sectors

We next present the results of the analysis of the mean scores for the Safety Leadership Model nodes in general and per business sector.

6.4.1.1 Safety Leadership orientations

The Safety Leadership related behavioural orientations of leaders were established by collecting the respondents' individual judgements on three statements concerning the (Task, Relation and Self-) behavioural orientations of their direct supervisor. They are represented in the general mean scores for the 34 Safety Leadership-related indicators as included in the survey questionnaire.

4 The underpinning statistical data is presented in Appendix 15.6.

6.4.1.1.1 *General mean scores for Safety Leadership orientations*

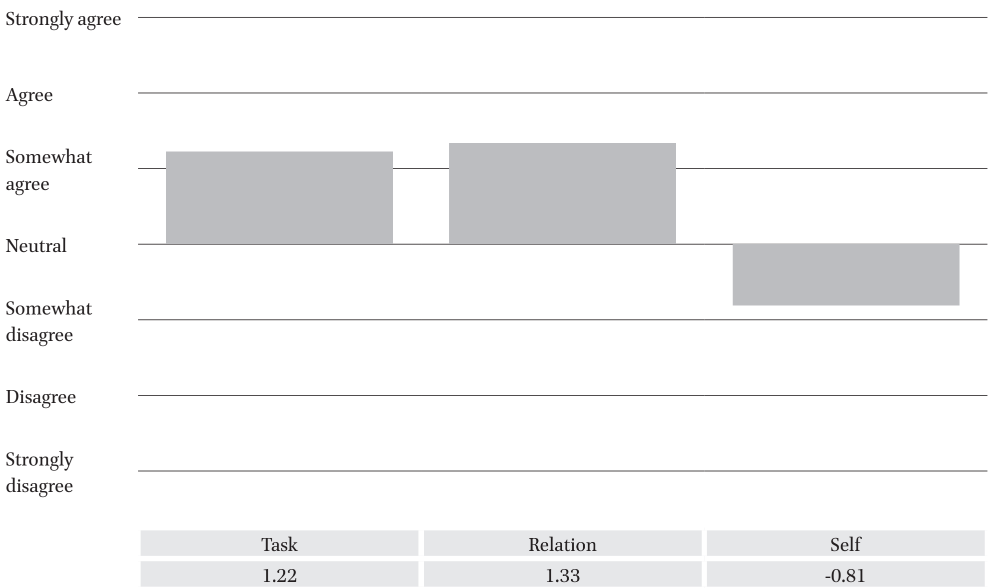
This section presents the leadership orientations of the respondents' direct supervisors in all organisations in general, as well as the mean scores per business sector.

Safety Leadership	Task	Relation	Self
Valid	3332	3332	3332
Missing	0	0	0
Mean	1.2223	1.3279	-0.8121
Std. deviation	1.00683	1.20012	1.13131

TABLE 6 Safety Leadership orientations by all general employees (N=3332)

The scores in the above Table 6 represent the perceptions of the population of general employees, and mean that these respondents, on average, *somewhat agree* that their direct supervisors show Task- and Relation-oriented behaviours, where a Relation orientation slightly prevails over a Task orientation (respectively M=1,22, SD=1,00 and M=1,33, SD=1,20). These respondents, on average, *somewhat disagree* that their direct supervisors show Self-oriented behaviours (M=-0,81 SD=1,13).

Bar Chart 6 below shows a graphical presentation of these scores.



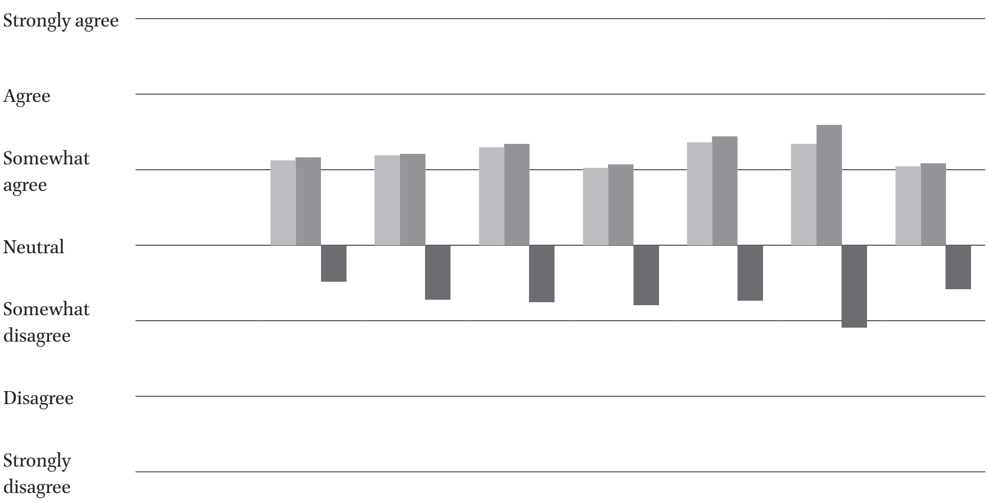
BAR CHART 6 General Safety Leadership profile by all general employees

Observations and interpretation of scores

These scores suggest that most of the respondents' direct supervisors show Relation-oriented behaviours, somewhat fewer leaders show Task-oriented behaviours and many fewer leaders show Self-oriented behaviours. However, the score for the latter category shows that there are respondents being supervised by Self-oriented leaders, otherwise this score would have been 'strongly disagree' (-3).

6.4.1.1.2 *Safety Leadership orientations per business sector*

The general data above presents the mean scores of non-sector specific data, which shows a picture of 'the respondents' world', which cannot be related to any specific source. We have also analysed the general means of the nodes of the Safety Leadership Model according to the different business sectors. The scores for Safety Leadership per business sector are shown in Bar Chart 7 below.



	Tank storage (n=185)	Hospitals (n=767)	Process industry (n=128)	Oil & gas (n=414)	Infra general (n=454)	Rail infra (n=1010)	Other (n=374)
Task	1.12	1.19	1.29	1.02	1.36	1.34	1.04
Relation	1.16	1.21	1.34	1.07	1.44	1.59	1.08
Self	-0.48	-0.72	-0.75	-0.79	-0.73	-1.09	-0.58

BAR CHART 7 Safety Leadership per business sector

Observations and interpretation of scores

Some remarkable scores were found in these data. The respondents in the tank storage sector showed the highest, *close to neutral* score for Self-oriented leadership behaviour (M=-0.48, SD=1.36). Leaders are more Relation-oriented than Task-oriented In all sectors. The general infrastructure participants stand out for their relatively high scores for Task-oriented leadership behaviour (*M*=1.36, *SD*=0.89). The rail infrastructure sector stands out regarding Relation-oriented behaviour (*M*=1.59, *SD*=1.06). This sector also has the lowest scores for Self-oriented leadership behaviour (*M*=-1.09, *SD*=1.02).

6.4.1.2 Risk Reduction Capacity

The general mean scores for Risk Reduction Capacity were established by collecting the respondents' individual judgements on the five phases of the Risk Reduction Cycle (Recognition, Ability, Motivation, Courage and Action). We present these mean scores for Risk Reduction Capacity in general, as well as the mean scores for each business sector.

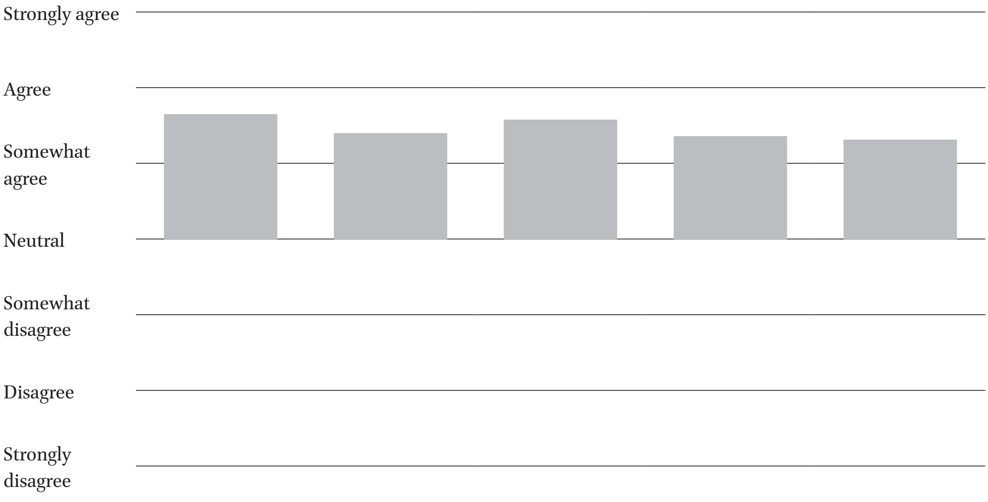
6.4.1.2.1 *General mean scores for Risk Reduction Capacity*

Risk Reduction Capacity	Recognition	Ability	Motivation	Courage	Action
Valid	3322	3320	3310	3297	3291
Missing	10	12	22	35	41
Mean	1.6508	1.4000	1.5782	1.3588	1.3102
St. deviation	1.28842	1.27988	1.31422	1.41341	1.45053

TABLE 7 Risk Reduction Capacity of all general employees

The scores in Table 7 above show how the general employees on average perceived the different levels of the five risk reduction phases. These scores mean that these respondents, on average, chose to *agree* that people at the work floor level recognise the safety risks in their working environment (*M*=1.65 *SD*=1.29). The respondents perceived that people at the work floor level had the ability to intervene when risks were recognised to a lesser extent (*M*=1.40 *SD*=1.28). In between the scores for these two risk reduction phases was people's Motivation to intervene (*M*=1.58 *SD*=1.31). The Courage to intervene scored somewhat less than Motivation (*M*=1.36, *SD*=1.41). Timely Action to solve safety risks scored lowest, but the respondents still scored slightly over *somewhat agree* concerning this risk reduction phase (*M*=1.31, *SD*=1.45).

A graphical presentation of these general scores is shown in Bar Chart 8 below.



Recognition	Ability	Motivation	Courage	Action
1.65	1.4	1.58	1.36	1.31

BAR CHART 8 Risk Reduction Capacity of all general employees

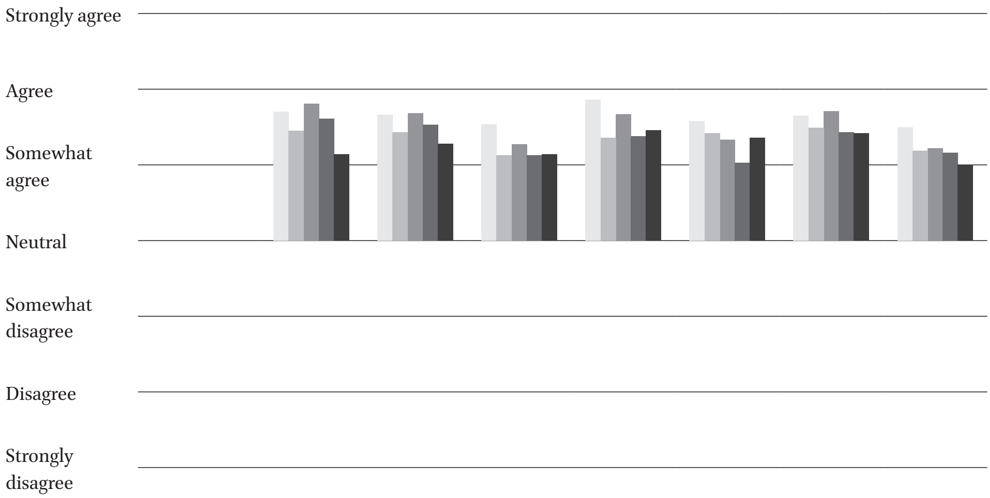
Observations and interpretation of scores

These scores show that the Recognition and Motivation risk reduction phases score relatively highly, and Action scores relatively low, which suggests that the respondents are convinced that they recognise risks relatively well, that they are motivated to intervene when risks are recognised, but that remedial Actions leave something to be desired. This coincides with the findings of Drupsteen,[5] whose case studies confirmed that the implementation of lessons learned from incident investigations was seldom performed systematically due to bottlenecks in implementing and communicating the Actions.

6.4.1.2.2 *Risk Reduction Capacity per business sector*

The different natures of the primary processes in the business sectors surveyed in this research mean that the risk reduction profiles of these sectors also show differences in the mean scores for their respective risk reduction phases. As we can see in Bar Chart 9, however, there are similarities too.

5 Drupsteen, Groeneweg and Zwetsloot (2013), p. 73.



	Tank storage (n=185)	Hospitals (n=766)	Process industry (n=127)	Oil & gas (n=414)	Infra general (n=453)	Rail infra (n=1005)	Other (n=373)
Recognition	1.70	1.66	1.54	1.86	1.58	1.65	1.50
Ability	1.45	1.43	1.13	1.36	1.42	1.49	1.19
Motivation	1.81	1.68	1.27	1.67	1.33	1.71	1.22
Courage	1.61	1.53	1.13	1.38	1.03	1.43	1.16
Action	1.14	1.28	1.14	1.46	1.36	1.42	1.00

BAR CHART 9 Risk Reduction Capacity per business sector

Observations and interpretation of scores

Our first observation is that the respondents in all sectors, except general infrastructure, report the Recognition and Motivation risk reduction phases as the highest scoring risk reduction phases in their respective sectors. The respondents working in the sector general infrastructure report the risk reduction phase Recognition as ranking first and Ability as ranking second. The respondents working in the process industry, oil and gas and general infrastructure sectors all perceive the risk reduction phase Action as ranking third. The other sectors, tank storage, hospitals, rail infrastructure and other, rank Action lowest of all risk reduction phases. In the tank storage sector respondents judge Courage (*M*=1.61 *SD*=1.43) relatively highly, and the general infrastructure sector scores lowest (*M*=1.03 *SD*=1.49).

The relatively overall high scores from the respondents in the oil and gas industry are of special interest, with Recognition (*M*=1.86, *SD*=1.21) as the highest scoring risk reduction phase of all sectors. The respondents working in the oil and gas industry also report a relatively high score for Action (*M*=1.46, *SD*=1.35). The oil and gas sector thus shows that risks are recognised *and* remedied more effectively than in other sectors. This might be explained by the fact that most of the respondents in that sector work *and* live 24 hours per day on isolated offshore platforms, surrounded by open sea, where the risk of a safety incident is the main safety threat, and the workers themselves are the potential victims of these safety incidents if risks are not recognised and remain unremedied.

6.4.2 *Safety*

The respondents were asked to respond to statements indicating their perceptions about their organisations' recent Event History (questionnaire statement used: "In the area of safety, a great deal went wrong within my organisations in the past year."), their present Sense of Safety (questionnaire statement used: "I feel safe in my organisation."), and their views on the future Risk Potential (statement: "The risk of an accident is real within my organisations.").

NOTE: The safety of organisations was not investigated during the early phase of this online prospective survey, because adding the 'safety' node to the Safety Leadership Model arose as a result of analysing the pilot survey. Due to this development, only 2006 respondents were offered the improved questionnaire which included the statements about 'safety.'

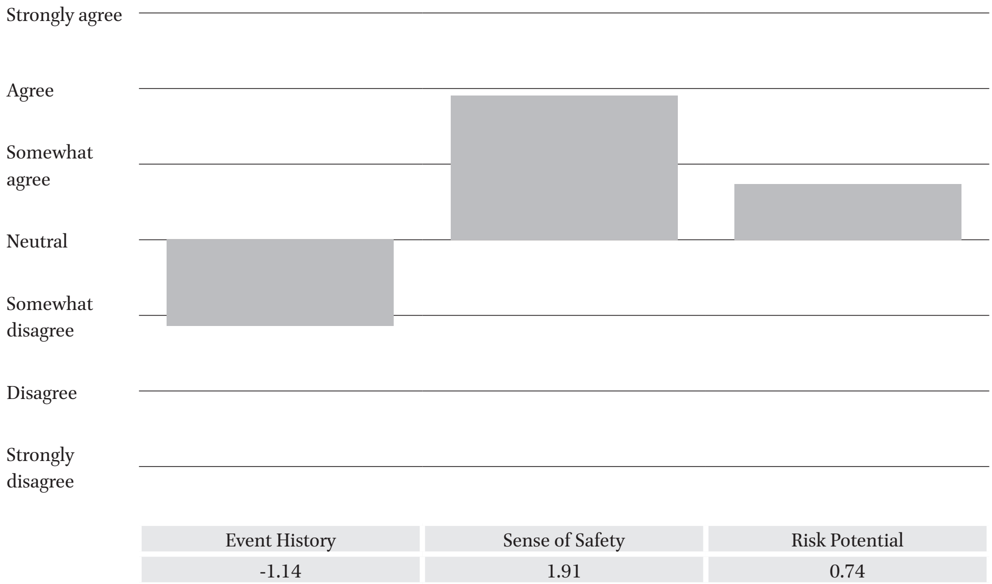
6.4.2.1 General mean scores for safety

Table 8 below shows the results of this part of the analysis of mean scores.

Result	Event History	Sense of Safety	Risk Potential
Valid	1906	2005	1991
Missing	1426	1327	1341
Mean	-1.1443	1.9102	0.7373
Std. deviation	1.50995	1.24732	1.75591

TABLE 8 Safety as reported by general employees

A graphical presentation of these scores is shown in Bar Chart 10 below.

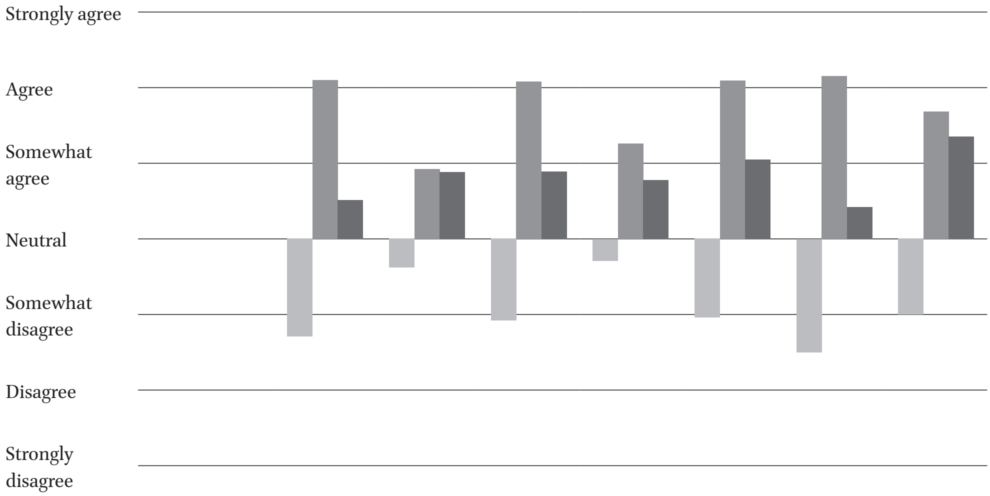


BAR CHART 10 Safety of all general employees

Observations and interpretation of scores

The scores in Table 8 and Bar Chart 10 represent the responses to the three statements above, and show that with respect to Event History the respondents, on average, *somewhat disagree* with the statement that 'a great deal went wrong in the area of safety' (*M*=-1.14 *SD*=1.51). The respondents indicate regarding their individual present Sense of Safety, that on average they feel safe (*M*=1.91, *SD*=1.25). The respondents, on average scoring between *neutral* and *somewhat agree* (*M*=0.74 *SD*=1.76), do not perceive potential safety risks as a real threat.

6.4.2.2 Safety per business sector



	Tank storage (n=98)	Hospitals (n=211)	Process industry (n=48)	Oil & gas (n=96)	Infra general (n=436)	Rail infra (n=901)	Other (n=215)
Event History	-1.29	-0.38	-1.08	-0.29	-1.04	-1.50	-1.00
Sense of Safety	2.10	0.92	2.08	1.26	2.09	2.15	1.68
Risk Potential	0.51	0.88	0.89	0.78	1.06	0.42	1.35

BAR CHART 11 Safety per business sector

Observations and interpretation of scores

As we can see in Bar Chart 11 the outcome data for safety shows some interesting scores. At first the hospital sector and oil and gas sector showed relatively high scores, close to *neutral,* for the 'Event History' variable (respectively M=-0.38, SD=1.57 and M=-0.29, SD=1.58), indicating that the respondents in these sectors consider that, safety-wise, a great deal went wrong in their organisation in the past year. These sectors score well above the mean score for this variable (M=-1.14, corresponding with: *somewhat disagree*). Remarkably the tank storage and rail infrastructure sectors reflect the opposite belief; both sectors score lower than *somewhat disagree* (respectively M=-1.29, SD=1.51 and M=-1.50, SD=1.31).

How the respondents experience their present individual Sense of Safety is closely connected to their scores for Event History; in sectors in which less went wrong last year (i.e., tank storage, process industry and general as well as rail infrastructure), the respondents score their Sense of Safety relatively highly; above *agree*. In the sectors with relatively high scores for Event History (i.e., hospitals and oil and gas), the respondents indicated feeling less safe; around *somewhat agree* (respectively M=0.92, SD=1.52 and M=1.26, SD=1.35). With respect to perceptions of the potential risk of accidents, all sectors except the 'other' group (*M*=1.35, *SD*=1.50) indicated lower scores than *somewhat agree* (*M*=1.00), resulting in a mean score of 0.74 (*SD*=1.76). The rail infrastructure sector estimate is exceptionally low, at close to *neutral* (*M*=0.42, *SD*=1.89).

6.4.3 *Correlation and regression analysis*

We analysed the correlations and regressions as applicable to the acquired survey data with respect to the three Safety Leadership orientations (Task, Relation and Self-) in relation to the data regarding the five risk reduction phases (Recognition, Ability, Motivation, Courage and Action). We also analysed the survey data acquired for the five risk reduction phases (Recognition, Ability, Motivation, Courage and Action) in relation to the data for safety characteristics (Event History, Sense of Safety and Risk Potential). Finally, we analysed the data concerning the three Safety Leadership orientations (Task, Relation and Self-) in relation to the data regarding the safety characteristics (Event History, Sense of Safety and Risk Potential).

A Spearman's Rank correlation analysis and a linear regression analysis were performed. These analyses were undertaken using SPSS Version 25.

6.4.3.1 Classification of identified values

The Safety Leadership correlation matrix presents the mutual correlations between Safety Leadership and Risk Reduction Capacity.

In order to evaluate the statistical power of the identified correlation levels, we refer to a hierarchical taxonomy of variables to produce empirical effect size benchmarks, as developed by Bosco et al.[6] Their Correlational Effect Size Benchmarks table (Appendix 15.4) refers to statistical power criteria as published by Cohen[7] in terms of uncorrected effect size (|r|). The criteria as published by Bosco et al. conclude that |r| values between .24 and .50 are classified as a 'medium' or 'moderate' effect size. We used this effect size classification as guidance during the interpretation of the correlations as described below.

The results of these analyses are presented in the following sections.

6.4.3.2 Correlation analysis

A Spearman Rank bivariate correlation analysis of the acquired survey data generated by 3332 respondents revealed the mutual relationship between aspects of the three different nodes of the Safety Leadership Model Version II (ref. Figure 23).

6 Bosco, Aguinis, Singh, Field and Pierce (2015), p. 433.
7 Cohen (2013)

6.4.3.2.1 *Interpretation of correlation analysis*

The outcomes of the correlation analysis suggest that Task-oriented leaders, and Relation-oriented leaders both relate in a significant and positive way to all phases of the Risk Reduction Cycle, whereas Self-oriented leaders had a significantly negative relationship with these phases.

We also observed that Task- and Relation-oriented leaders relate significantly and positively to the respondents' 'Sense of Safety'; whereas Self-oriented leaders relate in a negative way to this safety aspect. The reverse is true with respect to 'Event History'. The correlations between 'Risk Potential' and leadership orientations, as well as with safety, are negligible.

These observations are presented in Table 9 below.[8]

6.4.3.2.2 *Table of correlation coefficients*

	Recognition	Ability	Motivation	Courage	Action	Event History	Sense of Safety	Risk Potential
Task	.214**	.247**	.250**	.234**	.302**	-.293**	.463**	.025
Relation	.175**	.211**	.232**	.199**	.257**	-.275**	.444**	.026
Self	-.081**	-.093**	-.127**	-.099**	-.142**	.274**	-.311**	.044*
Event History	-.255**	-.257**	-.215**	-.245**	-.297**			
Sense of Safety	.250**	.251**	.221**	.199**	.283**			
Risk Potential	-.016	-.020	-.026	-.030	-.049*			

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

TABLE 9 Safety Leadership correlation matrix (N=3332)

The following is a detailed explanation of the above observations.

6.4.3.2.3 *Correlation between Safety Leadership and Risk Reduction Capacity*

Where the relationships between Safety Leadership and Risk Reduction Capacity are concerned, the following applies:

Task-oriented leaders may moderately positively influence the levels of every risk reduction phase (Recognition (r=.214, ρ=.000), Ability (r=.247, ρ=.000), Motivation (r=.250, ρ=.000), Courage (r=.234, ρ=.000) and Action (r=.302, ρ=.000)).

Relation-oriented leaders may be also moderately influencing the levels of the risk re-

8 Applied SPSS v.25 analysis: Bivariate correlation (Spearman Rank).

duction in the Motivation and Action phases (respectively r=.232, ρ=.000) and r=.257, ρ=.000). The have slightly less influence on the other risk reduction phases (Recognition (r=.175, ρ=.000), Ability (r=.211, ρ=.000) and Courage (r=.199, ρ=.000).

Self-oriented leaders only have a negative influence on Risk Reduction Capacity; all risk reduction phases correlate weakly negatively with this behavioural orientation (between r=-.081 and r=-.142, all orientations ρ=.000).

6.4.3.2.4 *Correlation between Risk Reduction Capacity and Safety*

As far as the relationships between Risk Reduction Capacity and Safety are concerned, we found the following correlations:

All risk reduction phases (Recognition, Ability, Courage, Motivation and Action) correlate moderately negatively with the '*Event History*' safety characteristic (between r=-.215 and r=-.297, all risk reduction phases ρ=.000). Low scores for risk reduction phases thus correlate with high numbers of actual incidents and vice versa.

Conversely, all risk reduction phases correlate moderately positively with the safety characteristic '*Sense of Safety*' (between r=.199 and r=.283, all risk reduction phases ρ=.000). So: high scores for risk reduction phases correlate with a high Sense of Safety.

None of the risk reduction phases showed a significant correlation with the '*Risk Potential*' safety characteristic.

6.4.3.2.5 *Correlation between Safety Leadership and Safety*

We found the following direct correlations between Safety Leadership and Safety:

Task-oriented leaders have a moderately negative relationship with the '*Event History*' safety characteristic (r=-.293, ρ=.000). So: leaders scoring highly for Task orientation are related to low incident numbers. Task-oriented leaders also have a strongly positive relationship with the respondents' '*Sense of Safety*' (r=.463, ρ=.000). *Task orientation* shows a very weak and non-significant correlation with the *'Risk Potential'* safety characteristic (r=.025, ρ=.259).

Relation-oriented leaders show similar correlations as their Task-oriented colleagues: leaders scoring highly for Relation orientation have low scores for 'Event History' (r=-.275, ρ=.000), and Relation-oriented leaders show a strong positive relationship with the '*Sense of Safety*' (r=.444, ρ=.000). Relation orientation shows a very weak and insignificant correlation with the *'Risk Potential'* safety characteristic (r=.0.026, ρ=.251).

Self-oriented leaders show a positive relationship with *'Event History'* (r=.274, ρ=.000). Leaders scoring highly for Self orientation are related to high incident numbers. The opposite applies to the relationship between Self-oriented leaders and '*Sense of Safety*' (r=-.311, ρ=.000); leaders scoring high on Self orientation, score low for *'Sense of Safety.'* Self-oriented leaders are very weakly correlated with the *'Risk Potential'* safety characteristic (r=-.044, ρ=.049).

6.4.3.3 Regression analyses

After establishing the correlations between Safety Leadership, Risk Reduction Capacity and Safety, we applied linear regression analyses to: 1) leadership behavioural orientations versus the risk reduction phases, 2) risk reduction phases versus the safety aspect, and 3) leadership behavioural orientations versus the safety aspects.

6.4.3.3.1 *Interpretation of regression analysis*

The associations identified between the different nodes of the Safety Leadership Model suggest that Task-oriented leaders are significantly and positively associated with all phases of the Risk Reduction Cycle. Relation- and Self-oriented leaders are considered to have negligible associations with these risk reduction phases.

We also observed that Task-oriented leaders are significantly and positively associated with the 'Sense of Safety'; whereas the association between Relation-oriented leaders and 'Sense of Safety' is negligible, and the association between Self-oriented leaders and 'Sense of Safety' is significantly negative. Task-oriented leaders seem significantly negatively associated with 'Event History', whereas the association between Relation-oriented leaders and 'Event History' is negligible, and the association between Self-oriented leaders and 'Event History' is significantly positive. Task- and Relation-oriented leaders are negligibly associated with 'Risk Potential', while Self-oriented leaders seem to be significantly positively associated with this aspect of safety.

The findings of this regression analysis suggest that a) Task-oriented leaders are positively associated with risk reduction and with the respondents' Sense of Safety, b) Self-oriented leaders have the opposite effect, and c) Relation-oriented leaders do not show any significant association with any of the risk reduction phases or safety aspects.

The observations described above are presented in the table below.[9]

9 Applied SPSS v.25 analysis: linear regression.

6.4.3.3.2 *Table of regression coefficients*

	Recog-nition	Ability	Motivation	Courage	Action	Event History	Sense of Safety	Risk Potential
Task	.356**	.349**	.279**	.346**	.510**	-.393**	.455**	.029
Relation	-.056	.003	.062	.006	-.028	.086	.089	.042
Self	.026	.054*	.019	.028	.005	.233**	-.072**	.138**
Event History	-.120**	-.102**	.011	-.048	-.202**			
Sense of Safety	.103**	.126**	.000	-.041	.207**			
Risk Potential	-.017	.007	-.001	-.024	-.072*			

** Regression is significant at the 0.01 level (2-tailed).
* Regression is significant at the 0.05 level (2-tailed).

TABLE 10 Safety Leadership regression matrix (N=3322)

A detailed explanation of the above observations is given below.

6.4.3.3.3 *Influence of Safety Leadership on Risk Reduction Capacity*
A regression analysis was performed to determine how the three leadership orientations (Task, Relation and Self-) influence the five risk reduction phases (Recognition, Ability, Motivation, Courage and Action). In this section we present the results of this analysis.

There was a significant association with a moderate effect size between the predictor variable Task-oriented leadership and the dependent variable Recognition risk reduction phase (b=.356; p=.000). The associations between the dependent Recognition variable and the predictor variables Relation-oriented leadership (b=-.056; p=.204) and the Self-oriented leadership (b=-.026; p=.301) proved to be non-significant.

Another regression analysis was performed to determine how leadership orientations influence the dependent variable risk reduction phase Ability. A significant association with a moderate effect size was found between the predictor Task-oriented leadership and Ability (b=.349; p=.000). The association between the predictor Self-oriented leadership and Ability is significant, but shows a weak effect size (b=.054; p=.028). The association between the predictor Relation-oriented leadership and Ability proved very weak and non-significant (b=.003; p=.950).

We performed a regression analysis to determine how the leadership orientations affect the Motivation risk reduction phase as the dependent variable. A significant association with a moderate effect size was found between the predictor Task-oriented leadership and Motivation (b=.279; p=.000). The associations between predictor Relation-oriented leadership and the dependent variable Motivation (b=.062; p=.163), and between the predictor Self-oriented leadership and Motivation proved both very weak and non-significant (b=.019; p=.450).

Finally, a regression analysis was performed to determine how the leadership orientations affect the Courage risk reduction phase as a dependent variable. A significant association with a moderate effect size was found between predictor Task-oriented leadership and the dependent variable Courage (b=.346; p=.000). The associations between predictor Relation-oriented leadership and the dependent variable Courage (b=.006; p=.904), and between the predictor Self-oriented leadership and Courage proved to be very weak and non-significant (b=.028; p=.311).

After conducting this correlation analysis, a regression analysis was performed to determine how the predicting leadership orientations affect the Action risk reduction phase as a dependent variable. A significant association with a moderate effect was found between the predicting Task-oriented behaviours and Action (b=.510; p=.000). The associations between the predictor Relation-oriented leadership and the dependent variable Action (b=-.028; p=.562), and between the predictor Self-oriented leadership and Action (b=.005; p=.855) proved to be very weak and non-significant.

6.4.3.3.4 *Influence of Risk Reduction Capacity on Safety*

A regression analysis was performed to determine how the five risk reduction phases (Recognition, Ability, Motivation, Courage and Action) affect the three safety characteristics (Event History, Sense of Safety and Risk Potential). We present the results of this analysis below.

First a regression analysis was performed to determine how the predicting risk reduction phases affect the dependent variable safety characteristic Event History. Significant, but weak negative associations were found between the predictor Recognition and the dependent variable Event History (b=-.120; p=.000), between the predictor Ability and Event History (b=-.102; p=.003) and between the predictor Action and Event History (b=-.202; p=.000). The associations between the predictor Motivation and the dependent variable Event History (b=.011; p=.742) and the predictor Courage and Event History (b=-.048; p=.133), proved to be non-significant.

Another regression analysis was performed to determine how the predicting risk reduction phases affect the dependent safety characteristic Sense of Safety. Significant, but weakly positive associations were found between the predictor Recognition and the dependent variable Sense of Safety (b=.103; p=.000), between the predictor Ability and Sense of Safety (b=.126; p=.003) and between the predictor Action and Sense of Safety (b=.201; p=.000). The associations between Motivation and Sense of Safety (b=.000; p=.991) and Courage and Sense of Safety (b=-.041; p=.115), proved very weak and non-significant.

A regression analysis was also performed to determine how the predicting risk reduction phases affect the dependent safety characteristic Risk Potential. A significant, but weakly positive association was found between Action and the Risk Potential (b=-.072; p=.036). All of the associations between the other four predicting risk reduction phases Recognition, Ability, Motivation and Courage showed very weak and insignificant associations with the dependent variable Risk Potential: Recognition (b=-.017; ρ=.676), Ability (b=.007; ρ=.863), Motivation (b=-.001; ρ=.988) and Courage (b=-.024; ρ=.546).

6.4.3.3.5 *Influence of Safety Leadership on Safety*

A regression analysis was performed to determine how the three Safety Leadership orientations (Task-, Relation- and Self-) affect the three Safety characteristics (Event History, Sense of Safety and Risk Potential). We present the results of this analysis below.

Initially a regression analysis was performed to determine how the Safety Leadership orientations affect the dependent safety characteristic Event History. A significant negative association with a moderate effect size was found between the predicting variable Task-oriented leadership and dependent variable Event History

(b=-.393; ρ=.000). A significant positive association was found between the predictor Self-oriented leadership and Event History (b=.233; ρ=.000). The association between the predictor Relation-oriented leadership and the dependent Event History (b=.086; ρ=.193), proved weak and non-significant.

A regression analysis was performed to determine how the Safety Leadership orientations affect the dependent safety characteristic Sense of Safety. A significant positive association with a moderate effect size was found between the predicting Task-oriented leadership and the dependent Sense of Safety (b=.455; ρ=.000). A significantly negative but weak association was found between Self-oriented leadership and the Sense of Safety (b=-.072; ρ=.010). The association between Relation-oriented leadership and the Sense of Safety proved to be weak and non-significant (b=-.089; ρ=.070).

Finally, a regression analysis was performed to determine how the Safety Leadership orientations affect the dependent safety characteristic Risk Potential. A significantly positive, but weak association was found between predicting Self-oriented leadership and the dependent variable Risk Potential (b=.138; ρ=.002). The associations between the predictor Task-oriented leadership and the Risk Potential (b=.029; ρ=.742), as well as between the predictor Relation-oriented leadership and the dependent variable Risk Potential (b=.042; ρ=.598) proved to be very weak and non-significant.

6.4.3.4 Evaluation of correlation and regression analyses

Conducting this correlation and regression analyses on the survey data generated by 3332 respondents meant that we gained clear insights into the relationships as well as the associations between the different components of the Safety Leadership Model.

The outcomes of the correlation analysis suggest that Task- and Relation-oriented leaders are positively related to risk reduction and the respondents' Sense of Safety and that the behaviours of Self-oriented leaders have the opposite effect.

The outcomes of the regression analysis suggest that Task-oriented leaders are positively associated with risk reduction and with the respondents' Sense of Safety, that Self-oriented leaders have the opposite effect and that Relation-oriented leaders do not show any significant association with any of the risk reduction phases or safety aspects.

These outcomes suggest that Task-oriented leaders have the potential to prevent the development of safety incidents, that the contribution of Relation-oriented leaders to this prevention process is not significant, and that Self-oriented leaders are considered to have a negative effect on operational safety.

6.5 Summary

In the next sections we present the preparation, process and results of an online prospective survey among 3332 general employees, working in 33 organisations, operating in six different specific business sectors. The theoretical framework, embedded in Version II of the Safety Leadership Model, served as an analysis reference. We analysed the mean scores of the Safety Leadership Model nodes in general, as well as per business sector. We performed correlation and regression analyses to identify the relationships and associations between the different nodes of the Safety Leadership Model. Below is a summary of the subjects discussed in this chapter.

6.5.1 *Mean scores*

Leaders in all sectors are mainly Relation-oriented, closely followed by leaders showing Task-oriented behaviours. Self-oriented leaders are a minority in all sectors, although this is a is relatively large minority in the tank storage sector and is relatively small in the rail infrastructure sector this minority. The rail infrastructure sector is found to be very people-oriented, with the highest score of all sectors for Relation-oriented leaders.

We see that there are two risk reduction phases that stand out in opposite ways: Recognition and Action. The respondents told us that safety risks are quite well recognised, but that remedial Action is often not implemented (or not in a timely way). If we look more closely, however, there is a distinction between hierarchical levels. In general, senior levels have a more optimistic view of risk reduction than operational staff. This applies specifically to Recognition and Action. Senior levels are very positive where these risk reduction phases are concerned, and respondents working in more operational areas are relatively positive about the recognition of risks, but often (very) pessimistic about whether remedial Actions are actually implemented. With respect to the other three risk reduction phases, Ability, Motivation and Courage, we found that in many sectors Motivation scores relatively highly (ranking second behind Recognition). Depending on the specific sector, Ability and Courage are either the third or fourth rank. Another distinction is the overall level of scores by support staff. This response group comprises mainly quality and HSE (safety) advisors. They prove to have a more critical view of the Risk Reduction Capacity of their organisations than their operations-affiliated colleagues.

We observed clear differences in mean scores concerning safety (Event History, Sense of Safety, Risk Potential). Two sectors, hospitals and oil and gas, reported relatively high scores for Event History compared with the other sectors. In contrast, the respondents in the rail infrastructure sector show the lowest Event History scores of all sectors.

The scores for actual Sense of Safety match the previous scores for Event History; the respondents working in hospitals and in the oil and gas industry report a much lower Sense of Safety than their colleagues in other sectors. The highest score of all sectors is shown in the rail infrastructure sector, but the respondents in the tank storage, process industry and general infrastructure also report feeling safe by giving high scores for Sense of Safety.

Respondents working in the rail infrastructure and tank storage sectors foresee the fewest problems regarding Risk Potential, but Risk Potential is not considered a reason for fear in any of the other sectors.

6.5.2 *Correlation analysis*

Correlation analysis identified significant relationships between the characteristics of the three nodes of the Safety Leadership Model. Task-oriented leaders were positively related to all phases of the Risk Reduction Cycle. Albeit to a lesser extent, this also applies to Relation-oriented leaders. We found that Self-oriented leaders were negatively related to all phases of the Risk Reduction Cycle.

Task-oriented leaders are negatively related to the safety characteristic Event History. To a lesser extent this also applies to Relation-oriented leaders. In contrast we found that Self-oriented leaders relate in a positive way to Event History. Task- and Relation-oriented leaders are both positively related to the safety characteristic Sense of Safety. Self-oriented leaders are negatively related to Sense of Safety.

Findings concerning the relationships between Task- and Relation-oriented leaders and the safety characteristic Risk Potential were not considered, as these did not meet the minimum requirements with respect to significance. Self-oriented leaders were weakly positively related to Risk Potential.

The regression analysis determined the associations between the characteristics of the three nodes, and dependent and predicting variables were determined. In this regression analysis design, safety characteristics are considered to depend on leadership orientations, acting in a predicting role, either in a direct hierarchical relation, or in a relation mediated by the phases of Risk Reduction Cycle. An analysis of the predicting leadership orientations and the dependent safety characteristics revealed certain significant associations. Task-oriented leaders are negatively associated with the dependent variable Event History, meaning that they are considered to *prevent* incidents. These leaders are also positively associated with the dependent variable Sense of Safety, which means that Task-oriented leaders are considered to have a positive effect on the state of safety. No significant effect was observed concerning the influence of Task-oriented leaders on the dependent variable Risk Potential, so people working for Task-oriented leaders do not see a significant association between their leaders and future safety risks. Self-oriented leaders are positively associated with Event History and Risk Potential, meaning that these leaders enable safety incidents and their followers expect a relatively high level of future safety risks. As an understandable coexisting effect, Self-oriented leaders have a negative influence on their workers' Sense of Safety.

Relation-oriented leaders are not significantly associated with any of the safety variables (Event History, Sense of Safety and Risk Potential).

6.5.3 *Regression analysis*

We observed the following with respect to the associations between leadership orientations and the risk reduction phases as dependent variables:

Task-oriented leaders are strongly positively associated with all phases of the Risk Reduction Cycle, meaning that these leaders have a positive effect on safety due to their positive effect on Risk Reduction Capacity. Self-oriented leaders are positively, but weakly, associated with Ability, meaning that these leaders have limited influence over the competences of their followers. Self-oriented leaders were not seen to have any significant influence over the other risk reduction phases. Associations between Relation-oriented leaders and any phase of the Risk Reduction Cycle were insignificant.

We discovered the following effects with respect to the associations between predicting risk reduction phases and dependent safety characteristics. Event History is negatively affected by the Recognition, Ability and Action risk reduction phases. This implies that these three risk reduction phases can be considered to have a preventive effect where safety incidents are concerned. Associations between the Motivation and Courage phases and Event History were insignificant. Sense of Safety is positively influenced by the Recognition, Ability and Action risk reduction phases. There were also no significant associations between the predicting risk reduction phases Motivation and Courage and Sense of Safety.

The dependent variable Risk Potential is weakly and negatively affected by the Action risk reduction phase. None of the other risk reduction phases had significant influence.

6.6 Conclusions of extended prospective research

The previous sections described the full process of an online prospective survey among a population of 3332 respondents, from the design of the survey questionnaire to a primary analysis of the survey results.

We present the conclusions of this preliminary analysis below.

Conclusions concerning the mean scores

Compared with the other three risk reduction phases, Recognition and Motivation scored relatively high. Two risk reduction phases stand out in opposite ways: Recognition and Action. The senior levels returned higher scores for Recognition and Action than operational staff. Operational staff had a positive view where the recognition of risks is concerned, but were (very) sceptical about the timely implementation of remedial Actions. Support staff (e.g., HSE) returned clearly lower scores than any other discipline.

Leaders in general were found to be mainly Relation-oriented, closely followed by leaders showing Task-oriented behaviours. Self-oriented leaders were a minority in all sectors.

We observed clear differences in mean scores concerning safety (Event History, Sense of Safety, Risk Potential). Event History scores were high in hospitals and the oil and gas sector, and lowest in the rail infrastructure sector. The scores for Sense of Safety were generally good, however the hospital sector and the oil and gas industry returned much lower scores than their colleagues in other sectors. Risk Potential did not result in interesting scores.

Conclusions concerning the correlation and regression analyses

The outcomes of the correlation analysis suggest that Task-oriented leaders and Relation-oriented leaders relate in a significant and positive way to all phases of the Risk Reduction Cycle; whereas Self-oriented leaders had a significantly negative relationship with these phases. Task- and Relation-oriented leaders relate significantly and positively to the respondents' Sense of Safety; whereas Self-oriented leaders relate in a negative way to this safety aspect. The reverse is true with respect to Event History. The correlations between Risk Potential and leadership orientations, as well as with safety, were negligible.

The findings generated by the regression analysis suggest that: a) Task-oriented leaders are positively associated with risk reduction and with the respondents' Sense of Safety, b) Self-oriented leaders have the opposite effect, and c) Relation-oriented leaders do not show any significant association with any of the risk reduction phases or safety aspects. The correlation analysis thus suggests that Task- and Relation-oriented leaders are 'safe' leaders and Self-oriented leaders should be considered a 'dangerous' group. The regression analysis also suggests that Task-oriented leaders are the 'safe' leaders, that Relation-oriented leaders have no significant effect on safety, and that Self-oriented leaders should considered a 'dangerous' group indeed.

6.7 Reflections by senior leaders

We considered it necessary to have the survey results appraised by the people this research is about. We thus approached senior leaders in organisations in the tank storage, hospital, oil and gas and rail infrastructure business sectors on an individual basis in order to obtain their thoughts on these survey results. If the organisations agreed, and depending on the logistical possibilities, we interviewed the CEO/managing director/board member or the most senior manager of the organisational unit considered, an operational/line manager of the unit and the safety manager/head of safety assigned to this unit. In total 38 leaders (9 CEOs, 8 board members, 9 senior managers and 12 safety managers). We shared our findings with these interviewees and asked them to tell us what these findings mean to them with respect to their individual views on safety leadership in their own organisations.

6.7.1 *Design of the reflection process*

All interviewees were informed about the survey results for their organisations well before the interviews took place. The interviews were conducted in a semi-structured way, guided by a pre-developed conversation guide. The primary objective of these interviews was to obtain the interviewee's specific feedback on the survey results generated by respondents working in the organisational unit for which they were responsible. A conversation guide, including the Risk Reduction Cycle, leadership in general and the informer's personal safety-related (incident) history, was used to structure the conversation. The duration of the conversations was between 60 and 90 minutes. Where this was considered of added value to the research, we allowed some room to include additional subjects introduced by the interviewees.

The interviews were conducted by the researcher. In all interviews the researcher was seconded by an independent experienced safety expert, acquainted with the design of this research and informed about the design and context of the interviews. This third person controlled the flow of the interviews, filled gaps where required, took notes and recorded the key items brought forward. All interviews took place at the premises of the interviewees. The conversation guide is presented in Appendix 15.8.

Various organisations asked the researcher to present their organisation-specific survey results at management meetings or safety-related sessions with staff members in different hierarchical positions (from CEOs to operational staff). All presentations took place at the organisation premises or at events organised by these organisations. After every presentation session we asked senior leaders to reflect on the survey results and to give us their opinion regarding the applicability of this survey method in an operational environment. The feedback received during these conversations has been amalgamated with the overview of people's reflections below.[10]

6.7.2 *Acquired reflections*

Although the reflections differed in each organisation, and often also depending on the hierarchical position within these organisations, all interlocutors told us that they understand the logic of the Risk Reduction Cycle and consider the resulting profiles clear and informative.

The survey respondents in most sectors perceived the Recognition and (secondary) Motivation risk reduction phases as relatively well implemented in their organisation and Action as the weakest phase. We asked the leaders to reflect on this. The generally high scores given by management (e.g., for Action) were considered curious, and sometimes debated by subaltern leaders ("we wonder whether management really knows what is

10 Each of the opinions was obtained shortly after the survey data for the particular organisation had been analysed. This implies that the conversations with senior leaders were conducted *before* we discovered the contradictions described in Section 6.8 and the consequential need to modify the leadership orientation Task to Production/Process. Reference is therefore still made to Task orientation in these reflections.

happening on the work floor"). The relatively low scores for Action by operational staff were generally recognised. The variation in scores for Courage at different organisational levels was clarified as due to the different roles of people operating on these levels. Some relatively low scores in specific departments could be explained by particular temporary situations, for example by issues with specific staff members, unrest due to reorganisation, and so on. In general, the participants showed broad agreement regarding the risk reduction profiles related to their organisations.

With respect to the effectiveness of safety leadership, all our interlocutors noted that personal involvement, mutual respect, clear responsibilities and related authority, empowerment and psychological safety were salient ingredients with which to improve the safety of risky operations. Nevertheless, we discovered from these conversations that not all organisations comply with the ideal leadership profile, and that different organisations in a single business sector demonstrate differences where leadership orientations are concerned. External influences seem to be crucial in the choice of a leader's behaviours.

These conversations produced a wealth of valuable data in terms of relatively common, but interesting views, about which risk reduction phases are strongly or weakly managed in the different business sectors, and which leadership orientations are applied by the leaders in the different organisations in these sectors. A summary of these reflections by the tank storage, hospital, oil and gas and railway infrastructure sectors is given below.

Tank storage

Due to some major safety issues, which have aroused increased interest from governmental inspectorates and the public press and media, the tank storage sector is closely supervised by the inspectorates. As a result of this reputational damage, organisations now understand that auditable risk management activities are important, not least in order to keep their licence to operate. There seems a relationship between the emphasis on operational risk reduction and experienced safety issues, and the consequential involvement of officials. This officials involvement is often heard as an argument used for paying increased attention to safety aspects.

All conversation partners in this sector told us that they consider a risk reduction profile to be a clear communication tool.

The risk reduction profile of the tank sector included high scores for the Recognition, Motivation and Courage risk reduction phases, and low scores for Action. Most leaders in this sector are Relation-oriented, closely followed by Task-oriented leaders. As in all sectors, Self-oriented leaders are the least common group, however, there were more Self-oriented leaders in the tank sector compared with all the other sectors in this research.

The tank sector scores second of all sectors for Sense of Safety, second lowest for Event History and second lowest for Risk Potential. These scores show that the respondents working in the tank storage sector feel safe, report few accidents and believe that the potential risk level is low. This picture is probably the result of the intense external pressure and consequential risk management activities initiated by the leaders in this sector.

Next, we refer to some organisation-specific reflections by senior leaders.

The leadership profile of Tank Storage Company A can be summarised as: Task orientation slightly higher than Relation orientation, and Self orientation relatively high compared with other organisations in this survey. Reorganisation in this company means that there are leaders assigned on a temporary basis. Their views on risk reduction were mixed, but certainly not positive. The most common opinion was that authoritative leadership is how the company is trying to recover from a difficult safety and commercial position.

Tank Storage Company B can be summarised as an organisation where the majority of leaders are Task- and Relation-oriented; there are some Self-oriented leaders present, but they are a small minority. All conversation partners consider the tank storage business as very Task-oriented; the 'satisfaction of clients' is paramount for management. Some conversation partners were surprised by the positive view held by management on the Recognition risk reduction phase, as in their view this risk reduction phase is 'somewhat poor' in the real world.

Relation-oriented leaders stand out in the leadership profile of Tank Storage Company C, there are less Task-oriented leaders and Self-oriented leaders are a small minority. The site director with whom we held a conversation, explained that he leads his people on the basis of trust, but at the same time requires his team 'to deliver.' The workers at an operational level experience this requirement as pressure, and they do not agree with the declaration of trust. In some departments the company suffers from serious dysfunction. This can be seen in the department-specific survey results.

The HSE director of this company was concerned about the low level of competence among operational staff. In the risk reduction profile this concern is clearly reflected in the low scores for the Ability risk reduction phase. In the HSE Director's opinion, not all team members are sufficiently competent, which is considered a handicap for the management policy of striving to empowerment. As an example of one serious danger, we were informed about the complacency of experienced staff with long track records, who ignore safety risks. It is suggested that this behaviour originates in the fact that incidents occur seldomly, and luck has been on their side for years. It is considered a serious risk that junior employees mistakenly consider these seniors 'professionals' and therefore adopt bad habits and unsafe methods, often for their own comfort or to increase production, in order to obtain individual compliments or bonuses.

The CEO told us that he recognises and understands the low score for the Action risk reduction phase; he sees his workers as fire-fighters, who are not focused on preventive actions, which are often planned by other departments and are put in process only after things have gone wrong. Although safety professionals are generally considered a very critical group, the CEO is surprised about the low-risk reduction profile scores by the support staff (mainly HSE officers). He is probably not aware, or ignores, the concerns regarding safety. The survey results for this company also clearly address the classical competition between the maintenance department and the production teams; maintenance does not trust operations, and vice-versa. An intervention by the site director quoted, operating on the basis of trust, seems useful here. The CEO would like to see his leaders as strongly empowered, but there is still considerable reluctance (fear?) among operational leaders; they told us that a mistake is easily made in this highly technical environment in which many manual operations are required, and 'losing face' is a serious reason to be careful rather than empowered. The CEO and the HSE director told us that they will consider adding the Risk Reduction Cycle to the safety toolbox of the company.

Hospitals

Since Hippocrates, health care workers have considered patient safety an important part of their daily work. These people are dedicated to their mission: 'Do no harm.' The type of work, high work load, psychological stress and complex processes in this sector, however, mean that workers are faced with many incompatible goals. Most patient safety depends on the individual risk awareness and safety motivation of doctors and nurses. In this complex environment with many uncertainties about the conditions of patients and the treatments required, slips, lapses and mistakes are easily made, and even small errors may result in major harm to patients. The representatives we met are aware of this, and are convinced of the importance of risk reduction. They believed the risk reduction profile was a clear communication tool.

Risk reduction profiles in the hospital sector reflect high scores for the Recognition, Motivation and Courage risk reduction phases, and lower scores for Action but the scores generated by different hospitals differ. The scores for Task- and Relation-oriented leaders were identical this sector, and relatively low for Self-oriented leaders. This sector shows a worried population as regards safety: the lowest score was for Sense of Safety, there was a medium score for Risk Potential and it had the second highest score for Event History (only the oil and gas industry had a higher incident record).[11]

Next, we refer to some organisation-specific reflections by senior leaders in this sector.

The leaders at Hospital D can be summarised as: Relation-oriented, with Task orientation second, and a small minority of Self-orientated leaders.

The leader-doctor we talked with believes that the hospital's risk reduction profile is realistic. He indicated that, as far as he was concerned, Recognition is the primary risk reduction phase, followed by Ability and Motivation. Courage is not worth talking about; you simply do what is necessary. Older generation doctors are important where safety is concerned; they do not always comply with new rules, such as the prohibition on wearing watches or closing their white coats; the younger doctors are more compliant. The younger doctors show less arrogant behaviour and are thus important in creating a safety

11 Due to the phrasing of the particular questionnaire statements, respondents working in hospitals probably related 'Event History' to safety incidents involving patients, and related 'Sense of Safety' to their own feeling about the safety in their hospitals.

culture. The leader-doctor considered 'Relation' the most important leadership orientation (which is confirmed for this hospital by the survey data).

Another conversation partner, a senior supervisor, agreed with the Risk Reduction Cycle; he considers the identification of serious risks and their immediate elimination as very important. He explained that Motivation depends on the particular individual. Courage is sometimes a difficult topic in this hospital. Some leaders behave in a Task-/Self-oriented way, but there is development to increasingly Relation-oriented leadership. The patient safety manager noted that there is insufficient compliance with the Action risk reduction phase (this is in alignment with the risk reduction profile produced by the survey data). Leaders suggest that they are supporting safety well, but the supporting advisors are of a different opinion. Budgets for safety improvements, promised by the board, do not always materialise, which hampers the solution of safety issues. According to this interlocutor, the Recognition of risks is a weak phase, and sometimes leaders do not want to acknowledge the existence of safety risks. External pressure from inspectorates or accrediting bodies has positive effects on the hospital sector. Accreditation is becoming compulsory in more and more workplaces and is considered very important. Many safety-related activities must be undertaken in order to obtain a Joined Commission International (JCI) certificate. The primary motivation to obtain such certificate is to ensure the continuation of business and retain a licence to operate. The CEO agreed with the Risk Reduction Cycle and said that it fit the hospital sector perfectly. He considered motivation the key bottleneck; in his view doctors are not interested in safety management systems and are relatively stubborn regarding compliance. Doctors believe in the quality of their own way of working. External pressure is effective to reduce resistance, but the hospital sector lags behind major hazard industrial sectors. Patients and governmental inspectorates play an important role in the improvement process. As a result of the accreditation process there is growing risk awareness. The CEO leads 'at a distance.' His style is a mix of Task and Relation orientations, because he is not an expert in a medical discipline. He believes that in order for the hospital to operate as he wants it to operate, it is important to show people the direction in which he wants them to move.

The leadership profile of Hospital E can be summarised as a mix of Task- and Relation-oriented. Self-oriented leaders are a minority. The doctor we met agreed with the risk reduction profile, especially where Recognition (high) and Action (low) are concerned. Action is often difficult to pursue due to incompatible operational goals. Time pressure is a major problem, which is only solved if more financial resources are allocated to reduce time- and work-pressure. External pressure is also an important lever with which to reduce safety risks in this hospital. Patient safety is in a relatively early stage of development; some structures (committees/tools) were recently put in place, and the decision to achieve JCI[12] certification has been recently taken. This is considered a positive development. The insurer has a positive effect on patient safety in this hospital. The CEO recognises the risk reduction profile; it was no surprise to him. He also specifically

12 Joint Commission International, an international certification institute in the health care sector.

recognised the low scores for the Action risk reduction phase. Regarding department specific scores, he believed he was able to trace the leadership orientation profiles back to individuals. These profiles perfectly match the people working in these departments.

The leadership profile of Hospital F can be summarised as Task-oriented, closely followed by a Relation orientation. Self-oriented leaders are a minority. The doctor charged with patient safety recognised (and understood why) the difference in risk reduction scores between managerial and operational staff. Action was the lowest scoring risk reduction phase on almost all levels. Management and senior staff set their own priorities, so improvements are only implemented when the individual concerned takes it as their personal and urgent chore. This is why the Action score is lowest. When external parties (the inspectorate and the press were mentioned) show interest in certain, especially safety-related, topics the sense of urgency is increased. The safety department returned relatively low scores for Risk Reduction Capacity, and the surgery department had a remarkably high score for Courage (!). The differences in scoring patterns are understood: the critical safety people on the one hand, the courageous surgeons on the other. An interesting observation is that the people in higher positions are perceived as less Self-oriented. The chairperson-doctor of the medical staff observed relatively high scores by management, which she considers nice, because this is interpreted as trust but Courage and Action score lowest (there was no further comment by this participant). The fact that the safety department returned relatively low scores is considered a logical consequence of the critical orientation of safety people. The high scores for Courage by surgeons are also well understood. The low score for Action does not surprise this chairperson-doctor; "We live here by the issues of the day. Everyone is busy and when there is no sense of urgency, action is lacking." The fact that senior staff scored Courage and Action relatively highly shows how mentally distant they are from the reality of the operational workers. Management trusts the information communicated by senior staff, but have no clue about what is going on at operational level. This doctor has not specifically reflected on the scores of leadership orientations. A senior staff member agrees with the risk reduction profile and thinks that the high score for Courage by surgeons is logical. He is not surprised about the relatively high scores for Action by department heads; they are the people responsible for action being taken. The low scores for Action by operational staff may be caused by a lack of feedback after actions are taken. The long timespan between identification of risks and completion of actions, may also be a reason that operational staff do not realise actions have been taken. According to this senior staff member, doctors choose 'quick-fixes', but these often do not lead to structural solutions. Many problems re-occur, because there is no long-term vision. The surgeons scored relatively highly for Self orientation, which this conversation partner understands very well but a similar score from the 'observing' disciplines is not understood. The hospital is considered a classic example of a hierarchical organisation. People with courage, an individual opinion and who are walking their own path, however, get everything done as they want it; to this senior leader these behaviours support the relative high Task-oriented scores. This applies only to the doctors, as the CEO is considered a more Relation-oriented person, who has to negotiate with many different disciplines in order to get support for his views. The hospital's CEO agrees with the Risk Reduction Cycle and understands the high Courage scores for the surgeons. He is not surprised about the low scores from his subordinates where Self-oriented leadership is concerned. The high scores for Self orientation by the surgeons are understood. He noted that more pronounced scores (high as well as low) given by higher hierarchical positions. In general, this participant recognised the scores that stand out, and states that he can relate these to certain individuals. He is surprised about the low perceptions of himself as regards 'stimulating innovation.' In his own perception he supports innovation, but apparently his subordinates perceive this differently.

Oil and gas industry

In the oil and gas industry also the risk reduction phase most positively scored is Recognition, followed by Motivation and Action. In this sector Recognition as well as Action are even scoring highest of all sectors. This indicates a relatively risk-aware population, which may be explained by the fact that the population in this sector, often working on isolated offshore sites or platforms, are the primary potential victims of safety incidents. In case safety risks are not identified or identified risks are not timely controlled by remedial Actions, vast amounts of energy may escape uncontrolled and situations may worsen too quickly to escape. This may explain the relatively safe behaviour of the respondents in this sector.

The leadership profile of Oil Company G shows an equal Task- and Relation-oriented leadership where a minority of Self-oriented leaders are present.

The respondents in this sector presented a relatively low Sense of Safety, a relatively high score for Event History and an average judgement where potential risks are concerned. This safety profile indicates a business sector where people are aware that incidents happen, and (for that reason?) do not feel they are in a safe situation. This profile most resembles the safety profile of hospitals, where safety is considered to be in an early development phase.

We had conversations with an ex-CEO, the operations manager, an area manager and the HSE manager. There was broad agreement among them about the importance of professional skills, knowledge and the competence of operational staff in safely operating primary processes. This was often mentioned in the context of a 'lack of risk awareness.' An example of operational risk was described as insufficiently trained staff being required to work in risky processes without being informed about the risks to which they are exposed. The operations manager stated that current incidents are much less serious than those 10 years ago. This positive development backfires, however, by reducing alertness regarding the occurrence of major incidents. The company therefore tries to increase risk awareness with the assistance of third-party experts; 'uncertainty' is one of the topics thoroughly discussed in this process. The operations manager specifically described positive experiences with the 'management of change' in the way that female leaders had tackled resistance. Mutual trust and empowerment are important aspects of leadership. This manager communicates to his subordinates that making mistakes is allowed, as long as people learn from these mistakes. Communication about safety risks is considered important; it is the first agenda item in the daily pre-work meeting, and this operations manager always attends this meeting. He felt that his presence leads to mutual respect and team spirit. The HSE manager explained that many people do not dare to speak up (Courage), and lack the required knowledge of safety risks (Recognition), as well as having insufficient knowledge to intervene (Ability). There is a general feeling that the opportunity for safety risks to become major incidents is underestimated. Time-pressure due to commercial targets is considered a disastrous factor. It leads to intuitive decisions by leaders, who, when in doubt, should take the time (and have the courage) to consult other resources. The safety manager claimed that his organisation works to create a culture in which mutual respect, and listening as well as talking (uneasy feelings), are key values: but he felt that the company wasn't there yet. The area manager also worried about small events with negligible consequences, which he saw as a sign that risk awareness is weakening. He considered Courage an important risk reduction phase; "Dare to speak up and dare to correct people showing risky behaviours!" In his opinion, mutual trust and personal relationships are also important aspects of leadership supporting risk reduction; he always tries to 'click' with operational staff on site. He hopes that if they are in doubt, they will call to ask his advice. He also noted that making mistakes is allowed, as long as all relevant colleagues in the organisation learn from it. He was brought up in a military family, and described himself as dual oriented: Relation-oriented during standard operational situations and Task-oriented for crisis-situations. This manager takes it that leaders must have integrity and be authentic, and not behave as if they are acting in a role-play.

All the participants from this company stated that a major incident acts as a wake-up call and serves as a trigger for a paradigm shift in safety policies. They indicated that there were too many minor incidents with the potential to become major incidents in their organisation. They all felt uncomfortable with this situation, and sought ways to improve it before major incidents arose.

The leadership profile of Oil Company H can be summarised as predominantly Relation-oriented, followed by Task-oriented and low Self-oriented leadership. This company was the first organisation in which we held our feedback conversations.

We communicated with three functionaries in a plenary meeting in this company. Our communication was mainly about the format for reporting the survey data, but some interesting feedback was received about the content of the reporting. The technical manager interpreted the scores for risk reduction as indicative of there being 'room for improvement', and he focused on the empty spaces above the bars in the bar charts. He thus judged high scoring respondents as being satisfied, and therefore without any urge to improve. He clearly recognised the profile of his managing director from the reported scores for specific leadership behaviours. The managing director also recognised himself in the profiles. With respect to the leadership behavioural scores, he suggested that the managers were very Action focused, which leads to lack of discipline concerning compliance with procedures. This is clearly shown by the leadership profiles as delivered and discussed. The HSE manager announced that the board of the company had decided to design a follow-up programme in which the survey results will serve as a 'basis for change.'

Rail infrastructure

Motivation scored highest in the rail infrastructure sector, closely followed by Recognition and Ability. Regarding Ability this sector shows the highest score of all sectors. Courage and Action scored almost identically and the lowest of all risk reduction phases.

The leadership profile of Company J is strongly Relation-oriented (the highest score in all sectors), followed by a Task orientation, with the smallest minority of Self-oriented leaders among all sectors.

The safety manager noted that people in operations indeed recognise safety risks quite well. Safety is part of the product of this sector. People are reluctant to take up tasks which they are not confident about, and tend to make decisions only when they feel supported by their supervisor. The high score for Motivation is confirmed by this participant. The safety manager was not surprised that the leadership profiles show mainly Relation-oriented people. This is explained as because it is considered important to be friendly among colleagues in this organisation, but this cultural aspect does not help to discriminate between competent and incompetent people, and therefore the CEO has expressed a wish to change this culture in order to empower employees to become stronger partners, especially to third parties. The management was afraid to be out of control after a major incident for which this organisation was responsible. The board thus increased their emphasis on supervision and 'track and trace' the progress of safety related plans and activities. The CEO is pushing employees to show more courage and take more autonomous positions.

A regional Manager Operations and Maintenance had entered the organisation recently and had not participated in the survey, but nevertheless accepted our invitation for a conversation. His statements are based on his experience during this short period of employment. This participant recognised the high scores for Relation- and the low scores for Self-oriented leadership. He questioned whether third party suppliers will agree with this, as the behaviour of respondents when among colleagues is different than when with third parties. The high score for Courage regarding respondents working in the department responsible for the trains being on time is not a surprise, as the people working in this department can (and should) make their decisions in a very autonomous way, so courage is virtually a requirement. That Courage is also scoring high in the finance department, is a surprise to this manager. The Chief Operations Officer (COO) of this organisation was not surprised about the high scores for Motivation, as he considered his employees very motivated, and having a positive orientation. The Action risk reduction phase was indeed considered a point of concern; many plans are agreed, but too often they are not followed-up. According to this manager, Action is the risk reduction phase 'where processes freeze.' He recognises that the traffic control department has better scores than any other department. He attributes this to the necessary job discipline for this type of work. He also recognises that the survey results show that people are predominantly Relation-oriented; good mutual relations are considered as important here. Where there is an emphasis on relations, however, the Action aspect is undermined; there is no culture of consequences, and people who do not comply with agreements are rarely criticised. This participant observed that the leadership orientation consists of indicators, which, from the point of view of a COO, could also be interpreted as Task-oriented; for example, impatience and courage could very well help to speed up projects. Nevertheless, these indicators had low scores, so this interpretation did not change the general view of the leadership orientation of this organisation. This COO supports the fact that his organisation shows up as mainly Relation-oriented.

A summary of the above reflections is given below.

6.7.3 *Summary of reflections*

It goes without saying that, the leaders of high-risk organisations understand and feel their responsibility where the prevention of major incidents is concerned. We assume that the medical mission "Do no harm" is unwittingly adopted by all leaders in all business sectors covered by this research, however, when push comes to shove, the fear of reputational damage and losing the license to operate plays an important role. The senior leaders who kindly accepted our invitation to reflect on the survey results were very open, honest and clear to us about their dilemmas; everyone proclaims 'Safety first', but sometimes the real world is a difficult place.

Major incidents, widely covered by the media and the consequent increased external pressure from inspectorates, were referred to as effective motivators for improving risk management activities. Obligatory certification/accreditation by independent certifying bodies (often imposed by governmental inspectorates) also plays a motivating role.

The tank storage sector made considerable progress in risk management after the sector faced unanticipated strong interventions by safety and environmental authorities, resulting in the compulsory shutdown of a whole tank farm. The hospital sector was shaken awake by publications about the number of patients who died after medical error, and now hospitals are working hard to develop better systems to prevent harm to patients. The oil and gas sector and their high level of safety are traditionally mentioned in the same breath, but for this industry the Piper Alpha disaster was needed as a tipping point, after which safety cases and safety management systems became compulsory and the industry's focus changed from being on human error by operators to a system approach which emphasised the role of management in major incidents.

The rail infrastructure sector proved to be something of the odd one out. Major incidents (e.g., train collisions) rarely happen and when they do, the focus of incident investigators is on train drivers (e.g., having passed red signals) or on the human error of railway workers. Investigators do not (yet) focus on the contribution of the leaders of rail infrastructure companies; maybe this explains why the survey results show the highest level of Relation-oriented leadership and the lowest level of Event History of all sectors.

In general, all participants considered the Risk Reduction Cycle an effective means of risk communication, and most also agreed with the risk reduction profile as applied to the organisations they work for. Nevertheless, various interviewees stated that some of the high scores by managerial respondents, especially for Recognition and Action, did not represent reality at the operational level. The low scores, mainly by operations-related respondents, for the Action risk reduction phase are well understood by senior leaders and the requirement to increase attention to remedial Action is confirmed by all participants.

6.8 Contradictions emerged

By comparing the data as acquired by the online prospective survey and the reflections as obtained from the senior leaders, we discovered two contradictions. The first relates to the analysis of the survey output data, which suggests that the Task-oriented leader should be considered a 'safe' leader. During their reflections, many of the senior leaders characterised the 'ideal leader' as a leader who demonstrates characteristics such as personal involvement, mutual respect, and empowerment and who ensures psychological safety. In our survey design, however, these terms do not match 'Task orientation': Task-oriented leaders are seen as achievers who focus on achieving production targets. It is also of interest to refer to the views of the 18 professional incident investigators (ref. 10.1), who argued that Task-oriented leaders are not considered a safe type of leader; the investigators even mentioned them as most instrumental in the causation of major incidents.

The second contradiction relates to the survey output data for the Recognition risk reduction phase, where we found a similar situation. The outcomes of the statistical analyses of the survey results show that Recognition is perceived as the risk reduction phase scoring highest or second highest, but various senior leaders stated that some of the high survey scores for Recognition, especially from managerial respondents, do not represent the reality at operational level. This statement was confirmed by the views of the consulted experts. The incident investigators suggested that the recognition of risks is considered the least controlled risk reduction phase (ref. 10.1). This view is supported by the five professional risk analysis experts (ref. 10.2), who suggested that a lack of understanding of safety risks, or ignoring them, often contributes seriously to the occurrence of major incidents. Moreover, the views of the incident investigators and risk analysis experts are supported by the view of the Dutch Safety Board (ref. 10.3), which mentioned a lack of recognition of risks as a contributing factor in the occurrence of major incidents in many of their investigation reports.

The above observations imply that some of the outcomes of the primary analysis of the online prospective survey results, as presented in this chapter, seem mismatched with the reflective opinions of the interviewed senior leaders, the retrospective views of professional incident investigators, the views of professional risk analysis experts and the conclusions as presented in investigation reports by the Dutch Safety Board.

Trust, but verify.
RONALD REAGAN

7 Reconsideration of primary prospective analysis

As mentioned in the previous chapter, we discovered two contradictions between the outcomes of the primary analysis of the online prospective survey results and results produced by different sources (i.e., senior leaders, incident investigators, risk analysis experts and the Dutch Safety Board). The contradictions involve: a) interpretations of the contributions of Task-oriented leaders to the causes of major incidents (further referred to as Contradiction #1), and b) the views of different parties regarding the scores for the Recognition risk reduction phase (further referred to as Contradiction #2). Based on these discoveries, we decided to reconsider the analysis process for the online prospective survey. This reconsideration process is discussed in this chapter, and the subsequent Version III of the Safety Leadership Model is presented.

7.1 Reconsideration strategy

Comparing a certain outcome to a predetermined undisputed reference leads to a result which shows whether the outcome meets or does not meet that reference. The reference itself is believed to be true and reliable in this process, and therefore not subject to reconsideration. Argyris[1] coined this approach as 'single loop learning.'

In the event that the source of the reference might possibly be subject to change, the reference itself could be included as part of the equation, and its validity also be questioned as part of the process. Argyris called this approach 'double loop learning.' Figure 24 below shows this single/double-loop model.

1 Argyris (1977), pp. 115–125.

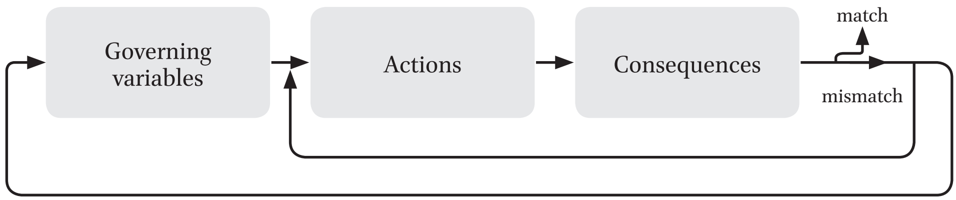


FIGURE 24 Single and double loop learning (Argyris)

Argyris explains this model using a comparison with room temperature control.[2] A room temperature (governing variable) is set according to the personal preference for room temperature of the people in the room. The adjustment of the thermostat (action) will instruct the heater to maintain the room at the preferred temperature (consequence). This represents a typical single loop process. When different people, who prefer a different room temperature, enter the room, the preference regarding the room temperature may change. If so, then this different preference (governing variable) is the motive for adjusting the thermostat setting (action), upon which the heater will change its behaviour, causing the temperature to change (consequence). This process, affected by changing the reference value, is a typical example of a double loop process.

With reference to measuring and monitoring against certain references, norms or standards, Baguley[3] explains double loop learning as follows:" … double loop learning takes place when a detection and correction process is applied to norms and standards. These norms and standards are subject to a process of measurement, monitoring, comparison and correction in order to establish if they are still relevant and appropriate. If they are not, they are changed ". We decided to refer to this single/double loop-concept as a methodological approach with which to reconsider the survey results. Our first reconsideration focuses on the validity of leadership orientations, because these were part of the survey references in the online prospective survey.

7.2 Task orientation-related contradiction

We developed a reference as part of this research: The Safety Leadership Model. The Safety Leadership node of this model contains three characteristics: the Safety Leadership orientations (Task, Relation and Self orientations). These Safety Leadership orientations represent certain combinations of indicators as included in the survey questionnaire. According to the model by Argyris (Figure 24), the Safety Leadership orientations serve as (part of) the Governing variables, conducting the survey represent the Actions, and the results of the survey are referred to as Consequences, which match or mismatch anticipated results.

2 Ibid., p. 116.
3 Baguley (1994), p. 18.

7.2.1 *Contradiction #1*

In this research we experienced a mismatch between the survey results, suggesting that a Task-oriented leader was a 'safe' leader, whereas the reflections on these results by senior leaders (ref. 6.7), as well as the views of the 18 professional incident investigators (ref. 10.1) suggested that Task-oriented leaders are the most instrumental in the causation of major incidents. This finding is an undesirable finding, and so we decided to investigate the origin of this contradiction.

The online prospective survey was conducted as a single loop process; the survey data generated by the respondents was analysed, using the Safety Leadership orientations as the undisputed reference (governing variables). To identify what went wrong, we referred to the theory by Argyris and decided to follow a double loop approach[4] by reconsidering the governing variables: the Safety Leadership orientations.

We decided to conduct two specific activities where the contradiction is concerned: a) the verification of the validity of the a-priori classification of the questionnaire indicators for Safety Leadership orientations, and b) the identification of the integrated dynamics of the Safety Leadership Model as a whole. Based on this decision we first verified the validity of the a-priori classification of the questionnaire indicators using two different types of factor analyses (EFA and CFA). After those analyses, we identified the integrated dynamics of Safety Leadership as a whole through Structural Equation Modelling. These activities are described in the following sections.

7.2.2 *Factor analyses*

The a-priori classification of the questionnaire indicators into the three Safety Leadership orientations (Task, Relation and Self) as used in this online prospective survey, was based on 21 indicators originating from leadership theory (ref. 4.2.3) and 13 indicators coined by the researcher referring to professional expertise in the field of risk management and safety. This survey questionnaire design was thus composed from different sources and its robustness and applicability were tested through a pilot survey among 88 professional experts. The reflections on the survey data by senior leaders in the surveyed organisations and the information obtained from risk analysis experts, however, meant that we thought a different classification of the questionnaire indicators into the three leadership orientations might be helpful. We therefore decided to seek proof of the a-priori classification of leadership indicators. We thus performed an exploratory factor analysis (EFA) and then (on a different sample) a confirmatory factor analysis (CFA).

4 Ibid., pp. 17–19.

7.2.2.1 Exploratory Factor Analysis (EFA)

Sample

The online prospective survey was conducted in two different phases. Once the pilot survey data had been analysed and (after implementation of some minor improvements) the robustness and applicability of the questionnaire was confirmed, we conducted an online prospective survey among another population of 3332 general employees (leaders and followers) working for the 33 organisations involved in this research. The original population surveyed comprised 4561 respondents. For data quality reasons, this was reduced by 1141 respondents (25.0%), leaving the data of 3420 (88 respondents in the pilot survey and a sample of 3332 respondents in the online prospective survey) to be taken into account. Section 6.2.3 shows how these respondents were selected.

The addition of the safety node to the Safety Leadership Model was one of the results of the analysis of the pilot survey. Safety statements were not included in the online prospective survey questionnaire from the initial survey phase. Due to this a-synchronicity, data about safety was not recorded by the initial group of 1326 respondents (39.8% of the total sample), to the survey questionnaire before the pilot survey was analysed. A total of 2006 respondents (60.2% of the total sample size of 3332) were presented with the improved survey questionnaire when the safety-related statements were included, so this group completed the entire questionnaire.

Analysis process (EFA)

The EFA was performed in order to classify the 34 leadership orientation indicators into consistent and discriminating factors. In order to minimise the risk of overfitting, the proposed EFA used a sample of 1326 (39.8% of the total sample size of 3332) respondents who had not been offered the safety statements. After the maximum number of identifiable dimensions was determined, the patterns of the loading factors for the EFA solution were examined. We checked the construct validity by applying a Cronbach's alpha evaluation to determine the internal consistency of the proposed factor structure of leadership orientations.

Classification of indicators

The EFA analysis demonstrated that 8 of the 34 leadership indicators did not meet the required statistical requirements. We found five indicators during the EFA procedure which were not compatible with their a-priori theoretical classification as suggested by the underpinning theory.[5] These indicators were removed from the analysis. We also found that three other indicators showed low loadings (< 0.25) or high cross-loadings, and therefore no classification for these indicators could be determined. Another item proved to be a dimension in itself as it did not load on any of the identified dimensions. These eight indicators were removed from the database, leaving 26 indicators to be classified into one of the leadership orientations.

5 Slocum and Hellriegel (2009), p. 368.

The EFA also included a classification of the leadership indicators into the suggested a-priori leadership typologies (*motivator, achiever*, *knowledge base*, *team player, stimulator, ruler* and *individualist*), as suggested in Section 5.1. The EFA revealed that the a-priori classification of some of the suggested typologies was insufficiently statistically supported by the survey data, and should therefore be revised. This revision encompassed quantitative (statistical), as well as qualitative (substantive meaning), characteristics of the different indicators, typologies and leadership orientations.

The leadership orientation Task was most affected in this optimisation process. The EFA analysis showed that the indicators which had been clustered to form this orientation actually represented *two* different constructs. Admittedly, both constructs relate to *achievers* (Task-oriented leaders), but the EFA analysis suggested that these leaders prefer using different leadership methods to achieve their goals, and are therefore considered to be differently oriented.

7.2.3 *Reconsideration of the leadership orientations*

We analysed the meaning of the survey indicators forming the two different Task-related orientations and we decided to split the Task leadership orientation into two distinctly different orientations. We found that one of the new orientations represents leaders who are characterised by achieving their objectives by acting decisively, behaving courageously and making intuitive decisions. In Atkinson's 'Theory of Motivational Determinants', the motivation of people to achieve certain goals is related to the risks they dare to take in order to succeed. Their behavioural motive is determined by their expectancy that their acts will lead to a particular consequence, and that these acts will be followed by a positive incentive. Atkinson claims that achievement motivation may lead to behaviour towards achieving the expected goal, but also to behaviour that aims to avoid failure (ref. 2.3.5.2). [6] In the following sections, the leadership type of leaders who demonstrate behaviours towards achieving an expected (economic) goal is called 'Production-oriented.'

The other (new) orientation represents leaders who typically demonstrate behaviours that aim to avoid failure. We called this leadership type 'Process-oriented.' These leaders are characterised by achieving their objectives by motivating their followers to intervene in safety risks, behave in a forgiving way, ensure that improvements are implemented and consider the safety of operations as top priority. Leaders who belong to a Production or a Process orientation are working to achieve production targets, but using different policies to succeed.

6 Atkinson (1957).

7.2.3.1 Production-oriented leaders

Leaders who behave Production-oriented are primarily focused on economic growth ("getting the job done, no matter what").[7] They show behaviours as *'power driven achievers'*, described by McClelland[8] as leaders, specialised in handling situations which call for something more than routine action, which implicitly involve taking risks of some kind (ref. 2.3.5.3) They operate with a focus on production targets and output: they are decisive and seem to be confident where, in reality, uncertainty is the case. This type of leader often has many years of operational experience, but (luckily) little personal experience with major incidents. These leaders lack sufficient risk awareness as well as the confirmation bias required to expect rare events, and they therefore underestimate the probability of such incidents; they honestly cannot imagine catastrophic scenarios happening under their leadership.[9] Leaders who lack the experience of critical failure are also overly optimistic about the effects of their decisions, as it is easy to imagine the successful completion of a project in the preparation phase, while the uncountable ways in which a project might fail are vague and elusive.[10] Steered by a lack of incident experience and ignorance, these optimists suffer from excessive confidence, due to which they behave decisively, courageously and take intuitive decisions.[11] According to Kahneman this optimistic bias is an important source of risky behaviour.[12] This behaviour, Kahneman's so-called 'System 1 behaviour', is typical of Production-oriented people.

7.2.3.2 Process-oriented leaders

Process-oriented leaders are also concerned with production objectives, but they demonstrate behaviours that are more contextually and socially motivated, as described by Winter[13] (ref. 2.3.5.4). These leaders take the possibility of surprises (e.g., the occurrence of safety incidents) seriously into account and consider uncertainty as an unmistakable element of their professional context. Process-oriented leaders believe in human potential (personal growth), always look for opportunities to do things more smartly, and motivate their followers to continually improve their performance.[14] Safety prevails; where safety risks are identified, time and effort are taken to reduce these to acceptable levels before operations are continued, and therefore they 'think twice' before taking a decision. Kahneman refers to this as 'System 2 behaviour.'[15] When Process-oriented leaders are faced

7 This description was given to this type of leaders by one of the incident investigators consulted in the retrospective review of incident analyses (ref. 9.1).

8 McClelland (1967).

9 Kahneman (2012), pp. 353–354.

10 Ibid., p. 347.

11 Ibid., pp. 343–356.

12 Ibid., p. 267.

13 Winter (1991).

14 Dweck (2012), pp. 125–127.

15 Kahneman (2012), pp. 259–269.

with a team member who has mistakenly interrupted the production process for safety reasons, they realise that people are fallible and they will forgive that team member their mistake.[16] In general, Process-oriented leaders endeavour to achieve their production targets in a more inclusive way, with equal focus on production and on the quality and safety-related aspects of the primary process. The behaviours of Process-oriented leaders show elements of multiple analogous leadership concepts, that is, High Reliable Organizing (HRO), psychological safety, a growth mindset and transformational leadership. We explain the relationship between these concepts and Process-oriented leadership.

We argue that when leaders exhibit behaviours matching the leadership concepts described above, they demonstrate that they possess the behavioural properties belonging to Process-oriented leaders. As our survey outcomes show, their focus and related behaviours will make a positive contribution to safety performance, and are the opposite of the focus and behaviours belonging to Production-oriented leaders.

7.2.3.3 Confirmatory Factor Analysis (CFA)

After the optimised taxonomy of leadership orientations proved internally consistent, we performed a CFA to verify the standardised loadings of the individual classified leadership indicators, as well as the mutual standardised loadings between the four leadership orientations as determined by the EFA. We used a different sample as the reference for this CFA analysis; the remaining 2006 (60.2% of the total sample size of 3332) respondents.

7.2.3.4 Internal consistency of leadership orientations

After completing the analyses as described above, we re-assessed the quality of the final taxonomy of leadership orientations by determining their respective construct validity (Cronbach's α). This assessment, using the test set (n=2006), revealed the following construct validity: Production (α=.76), Process (α=.79), Relation (α=.95) and Dominance (α=.82). These values indicate the good internal consistency of these four constructs.

7.2.4 *Explaining Contradiction #1*
The reflections by senior leaders

The results of the online prospective survey suggested that a Task-oriented leader was a 'safe' leader, however, when senior leaders in the surveyed organisations reflected on the survey results, they characterised the 'ideal leader' by mentioning features such as personal involvement, mutual respect, empowerment and psychological safety (ref. 6.8). The definition of Task orientation proved ambiguous in our survey design: Task-oriented leaders are considered achievers who focus on achieving production targets, but the so-

16 Dweck (2012), p. 127.

cio-psychological factors mentioned by the senior leaders were also included as indicators for Task orientation. This seemed to cause confusing results.

Based on our experience with the reflections on the survey data by senior leaders, we considered challenging the survey reference used (the three leadership orientations, Task, relations- and Self-), because we believed that a different classification of the questionnaire indicators might be conceivable. This was confirmed by the EFA.

The EFA suggested that Task-oriented leadership actually encompasses two different orientations: a Process orientation and a Production orientation. We also discovered that the indicators that make up the Process orientation resemble the description of 'ideal leaders' as mentioned by the senior leaders during the survey reflection process. From that discovery, combined with the knowledge of the outcome of the EFA, we take it that the senior leaders actually consider Process-oriented leaders to be 'ideal leaders.'

The views of incident investigators

Another discrepancy was the mismatch between the survey results and the views of the 18 professional incident investigators (ref. 10.1), the latter suggesting that Task-oriented leaders were considered the most instrumental in the causation of major incidents. Once we had completed the EFA-analysis we re-consulted these incident investigators in order to discover what they consider a Task-oriented leader. We presented them with the seven questionnaire indicators representing Task orientation and asked them to mark the indicators they considered typical of Task-oriented leaders. The results of this consultation are shown in Table 11 below.

A task-oriented leader …	**Responses**
… dares to take decisions based on his/her intuition	7
… has guts; does what he/she deems right, even when procedures prescribe otherwise	13
… dares to take decisions	15
… ensures that necessary improvements are made	**14**
… motivates employees to intervene themselves in case of safety risks	4
… says: "Safety first!"	5
… is forgiving when, out of caution, someone has unnecessarily disrupted production	3

TABLE 11 Leadership orientations consultation: results of incident investigators

The left side of the table shows the seven questionnaire indicators that, according to the questionnaire design, apply to Task-oriented leaders. The response column on the right shows the number of marks given by the incident investigators. The top three lines show the indicators of a Production orientation. The bottom four lines represent a Process orientation. The indicator printed in bold (… ensures that necessary improvements are made) has a factor load in common with both Process orientation (.35) and Production orientation (.31), so this Process orientation indicator might be called a 'shared' indicator.

We conclude from these responses that when the incident investigators suggested that Task-oriented leaders are considered most instrumental in the causation of major incidents (ref. 10.1), they referred to leaders who display a Production-oriented orientation.

7.2.5 *Conclusion on Contradiction #1*

The identified Task orientation-related mismatch involved the difference between the survey results (showing that Task-oriented leaders are 'safe' leaders) and a) the reflections on those results by senior leaders, and b) professional incident investigators (suggesting that Task-oriented leaders are considered most instrumental in the causation of major incidents).

The EFA and CFA analyses revealed that the 'Task orientation' construct actually encompasses two distinctly different constructs, a Process orientation (focusing on quality of the production process) and a Production orientation (focusing on quantity of production). This discovery resolved the identified contradiction.

7.3 **Recognition-related contradiction**

7.3.1 *Contradiction #2*

This mismatch concerns the difference in the outcomes of the statistical analyses of the survey results, showing that Recognition is perceived as the risk reduction phase generating the best or second-best scores. The professional incident investigators, however, argued the opposite; they suggested that the recognition of risks is considered the least controlled risk reduction phase (ref. 10.1). This argument is supported by the view of five consulted professional risk analysis experts (ref. 10.2), who suggested that lacking an understanding of safety risks, or ignoring them, often contributes seriously to the occurrence of major incidents. Moreover, the observations by investigators and risk analysis experts are supported by the view of the Dutch Safety Board (ref. 10.3), which noted a lack of recognition of risks as a contributing factor in the occurrence of major incidents in many of their investigation reports.

7.3.2 *Explaining Contradiction #2*

We noticed that the online prospective survey generated very high scores concerning the Recognition risk reduction phase. At the same time, we acquired very negative appraisals about Recognition from professional incident investigators, risk analysis experts and investigators of the Dutch Safety Board, who were all renowned experts in the field of risk management. Next, we show a selection of the acquired information.

Incident investigators

The 18 incident investigators were asked to analyse 19 major incidents, and they replied that, compared with the other four risk reduction phases, Recognition was the least controlled risk reduction phase (ref. 10.1). In a scoring system where the investigators could judge the contribution of a risk reduction phase on a scale from 0 (no contribution) to 5 (serious contribution), the investigators' judgements resulted in the following scores: Recognition 204, Ability 185, Motivation 156, Courage 151, Action 178.

Risk analysis experts

We individually interviewed five risk analysis experts, who possess substantial experience in the major hazard industry, and questioned them about risk awareness at the work floor level (ref. 10.2). One expert suggested that in general people in operations do know the safety risks, but also that there is a pattern of *normalisation of deviation*, meaning that certain deviations from safe practices have become the normal way of working; they know the risks, but they don't feel unsafe with them.

The other four experts explained that they consider that, for various reasons, operating staff have insufficient knowledge of risks. A lack of information communicated from risk analysis teams to operating staff seems an important reason. The answers to the question of whether supervisors are aware of safety risks are also cause for concern. Various reasons were mentioned, including lack of information, poor communication, and that risk analysis is considered 'owned' by technical departments. The experts were also worried about that operational leaders lacked knowledge about the major hazards.

Generally, the experts suggested that the identification and assessment of safety risks is a subjective and incomplete process, which does not produce a reliable representation of all potential safety risks. Moreover, organisations pretend that they have tackled all risks, but the interviewed experts wondered whether it was possible to identify and analyse all risks to begin with.[17] According to these experts, leaders live in an illusionary world, believing that their operations are safe.[18, 19]

Dutch Safety Board

We reviewed twelve investigation reports issued by the Dutch Safety Board (ref. 10.3). This stage of the research was introduced after we acquired the results from the incident investigators, who suggested that the insufficient Recognition of risks is in an important cause of major incidents. This suggestion was reason to investigate the role of recognition of safety risks in the causation of safety incidents in more depth. In our review of the incident reports from the Dutch Safety Board we focused on the role of risk awareness and risk assessment as contributors to these incidents.

We studied twelve investigation reports covering the tank storage, hospital, oil and

17 Pasman (2015), pp. 168–171.
18 Motet and Bieder (2017).
19 Beck (1986), p. 28–32.

gas industry, process industry, rail infrastructure and general infrastructure business sectors. We observed a high degree of Recognition-related conclusions. We note a selection here: "… one was not aware of the risks involved", "… the organisation was not able to use the knowledge of the safety risks involved", "… the company had no complete insight into its primary processes, installations and involved safety risks", "… as there was no effective hazard identification process, there was no complete picture of the major risks", "… risk identification of process safety risks was conducted in an insufficient way", "… risk identification of hazardous substances is insufficient and inadequate", "… in the HAZOP-study many risks of potential incidents have not been assessed…", "… none of the parties involved viewed this innovation as a particular risk for patients", "… nobody displayed awareness of the risks for patients due to this complex operation", "…insights into the interrelated risks were largely absent…", and "…risk assessments do not include the risk of trains colliding with heavy vehicles…".

Possible reasons for the mismatch in the recognition of risks

In this section we explain the Recognition-related mismatch wherein the above responses by risk management experts and professional incident investigators contradict the survey results concerning the Recognition risk reduction phase. In order to explain this contradiction, we refer to the underlying theory about the way people assess risk.

Slovic confirms the difference between the 'professional' approach to risk assessment by risk management experts versus an 'intuitive' approach by lay people. His research revealed that the experts, whom he refers to as 'technologically sophisticated analysts', employ risk assessment techniques to evaluate hazards, and that lay people rely on intuitive risk judgements. The expert seems to be the knowledgeable factor but that should be taken with a pinch of salt, because Slovic also argues that people in general suffer from similar biases resulting in the denial of uncertainties and misjudgement of risks (under- as well as overestimation) and that "… (perceived) characteristics such as familiarity, control, catastrophic potential, equity and level of knowledge also seem to influence the relationship between perceived risk, perceived benefit and risk acceptance."[20] These characteristics explain why the risk management experts and operational staff (often referred to as 'lay people'), who occupy different positions, have different kinds of experiences, play different roles in organisations and judge risks differently.

In an article entitled "Characteristics of Individual Risk Perception" Jungermann and Slovic suggest that controversies about risks are often caused by the question of which criteria are to be used and how these are to be weighed in a risk assessment process. These scholars argue that: "These questions cannot be solved scientifically, but only socially and politically."[21]

Some of the risk analysis experts suggested to us that people in operations are aware of the safety risks they run, but that due to a lack of serious incidents, there is a trend

20 Slovic (1987), pp. 282–285.
21 Jungermann and Slovic (1993), p. 100.

of *normalisation of deviation*, meaning that certain deviations from safe practices have become the normal way of working. We touch on non-compliance with safety directives here, which implies that people who are indeed aware of the actual safety risks, do not consider these risks threatening enough to comply. Our participants/risk analysis experts claimed that this observation is often made in relation to operational staff, and, because the behaviours of this group are so easy to observe and address, these people are often blamed for 'pulling the trigger' in safety incidents, and therefore considered responsible for the consequences.

Theorists tell us about a related, but very different trend: the ignorance of risks by leaders. In his review of the BP Texas City refinery disaster, Hopkins[22] argues:

> … managers knew that the longer they continued operating in a degraded state, the greater the tendency to "normalise" the situation, that is, to accept the greater level of risk as normal. The normalisation of risk has been a significant factor in many major accidents. For example, prior to the Challenger and Columbia space shuttle accidents, a certain level of equipment malfunction came to be accepted as normal because it had not in the past led to disaster. People became desensitised to the risks of operating in this way. Ultimately, these malfunctions proved fatal.

We recognise these phrases by Hopkins, because people who work in a specific physical and cultural working environment may easily be 'intoxicated' by the 'way we do things over here' (also explained as 'culture'), and, as a result, honestly do not realise the present risks, even if these are obvious to third party observers.

Perrow[23] refers to the safety risks that were ignored by NASA and finally resulted in the well-known shuttle disasters. He notes the "corrupted safety culture" and the "extraordinary display of power that overcame the engineers who opposed the launch", and he also refers to the normalisation of deviance as a serious risk potential leading to major incidents.

Another possible reason people become used to working under risky conditions is their dependence on the income; if they complain about safety risks, they run the risk of being dismissed. In such cases people undertake their own risk assessment and weigh the risk of getting hurt against the risk of becoming jobless. Hierarchical power is also a factor to take into account regarding whether people report safety risks. Perrow notes that power is a critical aspect of safety, when he suggests that people do not dare to refer to safety risks until they have, willingly or unwillingly, left the organisation, and in that respect, he states that "we miss a great deal when we substitute safety for power."[24]

Jungermann and Slovic explain that the concept of risk should considered many-layered, and that controversial and individual risk perception is a function of both the qual-

22 Hopkins (2008), p. 45.
23 Perrow (1999), p. 380.
24 Ibid., p. 380.

ities of our cognitive and motivational system, as well as of the conditions of our social, political and cultural environment.[25] Organisational socio-psychological norms may also affect the assessment of risks by employees; in "macho cultures" workers may receive psychological rewards for risk taking, when they honestly do not see the risk anymore.[26] We argue that risk acceptance is also strongly dependent on the specific business sector in which people work; for example flying helicopters scores highest on the 'most dangerous activities list' (even above motor cycle riding!) and, although oil companies proclaim 'safety first', workers on offshore platforms are frequent helicopter passengers in order to commute from their homes to their work places Medical doctors work many more hours than legally accepted in other business sectors, where fatigue is considered a safety risk. It is very easy to find many other examples. We therefore argue that economy and safety are out of balance in many sectors, and that this is not a case of not recognising the safety risks, but merely a case of personal preference.

Finally, we refer to the fact that recognising risk requires an understanding of the future; what is the most probable future outcome? Motet[27] argues that the main problem is that our knowledge of the future in principle is zero, and the concept of risk is considered a tool used by experts who claim to possess superior knowledge of future threats. This may also have affected the judgements made by incident investigators, risk analysis specialists and the Dutch Safety Board. It is appropriate here to recall the relatively low survey scores we received from support staff, the internal safety experts, who proved to have a more critical view than any of their colleagues in the survey.

Compared to internal experts, external experts have the advantage of their broad experience, which provides them with a much wider window through which they have seen many risky situations, not visible to internal people. External experts who have witnessed so many risky situations and personally seen the disastrous results of many uncontrolled safety risks, are inevitably subject to confirmation as well as hindsight bias, when asked to assess the recognition of safety risks. Actually, it would be curious if these external experts came to the same conclusions as internal respondents.

7.3.3 *Conclusion on Contradiction #2*

According to the above explanations, the origin of the mismatch may be considered a result of "unknown knowns", which are explained by Aven as "… events not on the list of known events from the perspective of those who carried out a risk analysis (or another stakeholder), but known to others (unknown events to us, known by others)."[28] According to Kahneman, however, human optimistic bias is an important source of risky behaviour, and we tend to overestimate the benefits and underestimate the costs. We

25 Jungermann and Slovic (1993), p. 87.
26 Perrow (1999), p. 246.
27 Motet and Bieder (2017), p. 7.
28 Ibid., p. 28.

develop successful scenarios while not taking the potential errors and miscalculations into account.[29] This might be considered ignorance, but the frequent major incidents worldwide demonstrate that we are not good enough at recognising risks. In that respect we repeat the phrase by Slovic:[30]

> … danger is real, but risk is socially constructed. Risk assessment is inherently subjective and represents a blending of science and judgment with important psychological, social, cultural and political factors.

Probably even more importantly, Slovic stated: "Taking into account information that does not come to our mind, perhaps because we never knew it, is impossible."[31]

We argue that the arguments above have contributed, each in its own specific way and with a different grade of impact, to explaining the contradiction in judging the Recognition of risks as identified in this research. Both groups, the survey respondents as well as the experts, have contributed to this research a great deal through the unintended generation of this contradiction. We have learned through their contribution that general employees, who are considered very familiar with their primary processes, are optimistic (leaders even more than operational staff), probably overly optimistic, about the level of Recognition of safety risks in these primary processes, and three different kinds of renowned risk management experts have made opposing assessments of the very same reality, for which nobody will ever completely know all the risks. Nobody is able to calculate how many risks are still in the uncertain domain of the unknown. Thaleb has written: "We love known schedules and well organised knowledge, even so much so that we are blind to reality."[32] We conclude that solving the contradiction is not required, but being aware of the gap is considered a contribution to safety in itself.

7.4 Concluding taxonomy of classification of leadership indicators

As a result of reconsidering the leadership orientations (ref. 7.2.3), the leadership indicators were reclassified. The outcomes of the factor analyses (EFA and CFA) show that the total set of leadership indicators suggests the existence of four different leadership orientations, instead of the previous three orientations: Task, Relation and Self orientations. The Task-oriented indicators in particular have proven not to hold statistically as one single orientation, but instead, to belong to two different orientations. Taking into consideration the specific properties of the seven Task-related indicators concerned, we decided to label these two new orientations 'Production' and 'Process' (ref. 7.2.3). This results in a final taxonomy of 26 indicators clustered in four leadership orientations: Re-

29 Kahneman (2012), p. 267.
30 Slovic (2001), p. 23
31 Kahneman (2012), p. 277.
32 Taleb (2010), p. 148.

lation, Process, Production and Dominance. This is presented below in Figure 25.

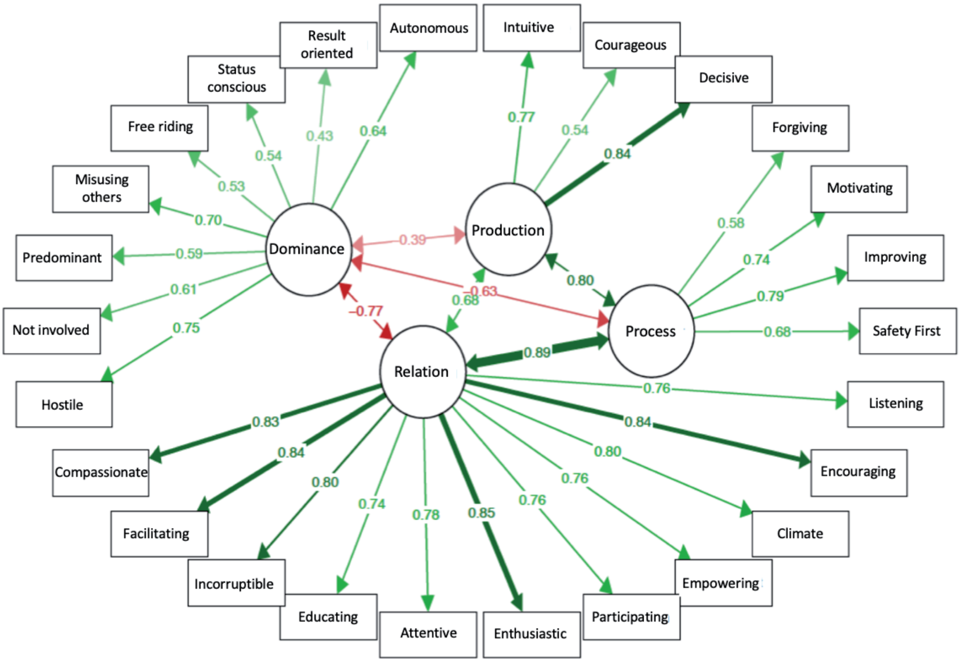


FIGURE 25 Leadership indicator taxonomy and factor loadings by leadership orientation

7.5 Safety Leadership Model Version III

The outcome of the exploratory and confirmatory factor analyses on the Safety Leadership node of the Safety Leadership Model recognised the redefinition of the leadership orientations and thus required upgrading the Safety Leadership Model Version II to Version III. This upgrade, as described in this chapter, encompassed the specification of Task orientation leadership by introducing two new leadership orientations, Production- and Process orientations. We also included the option of Safety Leadership having a direct effect on safety, not mediated by Risk Reduction Capacity. We added a new arrow between Safety Leadership and Safety. The final Version (III) of the Safety Leadership Model is presented below (Figure 26).

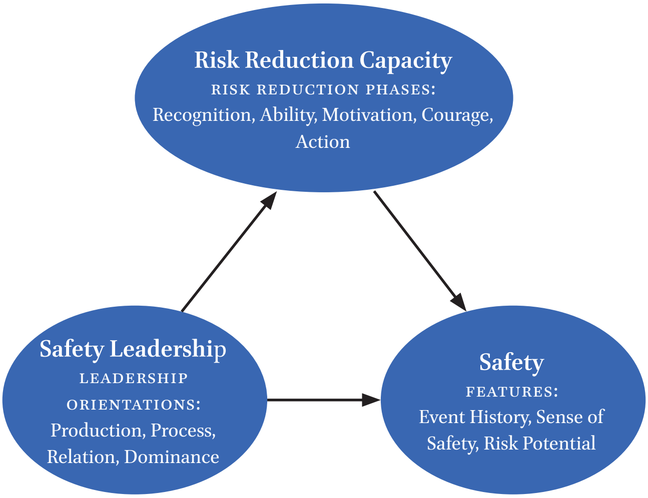


FIGURE 26 Safety Leadership Model Final Version III

7.6 Summary

After discovering two contradictions between the results of the online prospective survey and a) the interpretation of the contribution by Task-oriented leaders to the causation of major incidents, and b) the views about the contribution of the Recognition risk reduction phase to risk reduction in the previous chapter, we decided to reconsider the analysis process of the online prospective survey. We discussed this reconsideration process in this chapter.

First, we explained and applied the single/double loop model by Argyris. This model directed us to focus on a reconsideration of the survey questionnaire indicators referring to the Safety Leadership orientations. We decided to conduct an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA). Then we discovered from these analyses that the Task orientation construct was not an unambiguous concept. Actually, it encompasses two different constructs, each representing a different policy of leadership. This finding required a reclassification of the Task-oriented survey indicators. We thus solved this contradiction and modified the classification of the leadership orientations. This had important implications for the typologies. These implications are presented in Section 7.4, 'Concluding taxonomy of classification of leadership indicators'.

With respect to the leadership orientation Task, the term *Production* replaced the typology *achiever* and the term *motivator* was renamed as the now more applicable term *Process*. The suggested typology *knowledge base* was deleted, as the related group of indicators was not supported by the EFA analysis as a distinct construct. The suggested subdivision of the Relation orientation into the typologies *team player* and *stimulator* was not supported by the EFA analysis, so these typologies were combined into one orientation: Relation. The EFA showed a similar situation regarding the orientation Self: the suggested split into *ruler* and *individualist* was not statistically valid, so Self orientation survived as a single variable. In order to improve communication/understanding we translated the term Self orientation as Dominance orientation.

The above changes resulted in the following terminology: production-oriented leaders are primarily focused on meeting production targets; Process-oriented leaders are focused on the improvement of processes and have fundamental respect for the quality and safety-related aspects of the primary process; Relation-oriented leaders value interpersonal relationships and care for the social climate at the work place; and the Dominance-oriented leadership orientation encompasses self-centred, sometimes even narcissistic leaders, who are only interested in their personal priorities.

We also investigated another contradiction between the survey results as generated by general employees and the views of the consulted experts about the contribution the Recognition risk reduction phase makes to risk reduction. The different data proved to represent reality and is considered a logical effect of the different roles and perspectives of both groups (internal employees and external experts). We therefore concluded that the difference identified between the survey results and the views of the consulted experts has no effect on the content of this dissertation.

7.7 Conclusions

Due to the discovery of two contradictions between the survey data and otherwise acquired information we reconsidered the classification of the Safety Leadership orientations. We performed exploratory and confirmatory factor analyses. These analyses revealed that the Task leadership orientation actually encompasses two distinctly different orientations, called Process and Production. We thus recognised four instead of three leadership orientations: Relation, Process, Production and Dominance. This required an update of the taxonomy of leadership indicators, which led to a modification of the Safety Leadership Model into Version III. These changes solved Contradiction #1 concerning Task-oriented leaders.

Contradiction #2 between the survey data and information acquired otherwise was related to the Recognition risk reduction phase. Investigating that mismatch did not eliminate the contradiction, but its existence was satisfactorily explained as a result of the explainable different views held by internal operational employees and external risk management experts.

In the next chapter we will submit the results of the online prospective survey, using the Safety Leadership Model Version III as a reference. The mean scores of the survey data will be discussed. The causative relationships between the nodes of the Safety Leadership Model are determined using Structural Equation Modelling (SEM), which forms the basis for the answer to the principal research query: "Can leaders of organisations help to prevent safety incidents?"

We would have to wait too long to accumulate empirical evidence to prove whether a failure probability was really one in 100.000 years or actually one in 10.000.

ANDREW HALE

8 Prospective survey results

8.1 Introduction

We conducted an online prospective survey as part of our exploration into the principal research query: "Can leaders of organisations help to prevent safety incidents?" During factor analyses (EFA/CFA) of the survey data, we discovered two contradictions. Due to that discovery, we reconsidered the validity of the survey reference, the Safety Leadership Model. This resulted in an upgrade of the model to Version III (Figure 26) as presented in Section 7.5. The initial set of three leadership orientations (Task, Relation and Self-) was changed to a set of four leadership orientations (Relation, Process, Production and Dominance). This required a review of the analyses of the survey results. The Safety Leadership Model Version III served as the reference framework in this review. The results of these analyses delivered the proof required to resolve the principal research query. In this chapter we explain how we have obtained this proof.

First, in Section 8.2, 'General mean outcomes', we show the mean scores of the respondents' perceptions in relation to the three nodes of the Safety Leadership Model. In Section 8.3 we present the mean scores for five additional moderator variables (gender, hierarchy, age, vocational experience and incident history). In order to establish the value of this research for safety improvements, we asked the senior leaders of surveyed organisations to reflect on the research results. This reflection process and a summary of the feedback by senior leaders was presented in Section 6.7. The effects of the four different leadership orientations on risk reduction, as well as on safety, was established through Structural Equation Modelling (SEM). The outcomes of this SEM path analysis are shown in Section 8.4.

8.2 General mean outcomes

In these sections we present the responses of the general employees in terms of the general results and the results for each business sector regarding the safety leadership orientations of their direct leaders, their organisations' risk reduction capacities and their average perceptions of safety. We also report the outcomes related to the additional moderator variables: gender of supervisors, hierarchical positions, vocational experience, age and major incident experience. Our presentation follows the structure of the Safety Leadership Model; first we present the outcomes with respect to the leadership orientations, then we show the outcomes regarding Risk Reduction Capacity, and in conclusion we present the outcomes regarding safety. We present the underpinning statistics and related graphs in Appendix 15.6.

8.2.1 *Safety Leadership orientations*

8.2.1.1 Safety Leadership: General mean scores

The mean scores of the general employees concerning the Safety Leadership orientations show that these respondents, on average, *somewhat agree* that their direct supervisors show Process- and Relation-oriented behaviours, where Process orientation slightly prevails over Relation orientation (respectively M=1.34, SD=1.07 and M=1.33, SD=1.20). The members of this population, on average, *somewhat disagree* that their direct supervisors show Dominance-oriented behaviours (M=-0.81 SD=1.13). These results are graphically presented in Section 15.6.1.1.

8.2.1.2 Safety Leadership: Mean scores per business sector

The employees of 33 organisations, operating in six different specific business sectors responded to the online prospective survey questionnaire. The distribution of the respondents over the business sectors is not identical due to the differences in staffing at the participating organisations. The contribution of general employees from the rail infrastructure sector (1010) and the hospital sector (767) is relatively large, and fewer employees from the process industry (128) and the tank storage sector (185) participated. The response from the oil and gas industry (414) and the general infrastructure sector (454) is located between the other categories. The category ‘other’ represents respondents who participated as attendees in symposia, courses and workshops, and whose business sectors are not known.

The distribution of respondents over the six specific business sectors and one general sector ‘Other’ is presented in Table 12 below.

	Frequency	Percent
Tank storage	185	5.6
Hospitals	767	23.0
Process industry	128	3.8
Oil & gas	414	12.4
Infra general	454	13.6
Rail infra	1010	30.3
Other	374	11.2
Total	3332	100.0

TABLE 12 Distribution of respondents over business sectors

In the acquired data we found that the Process leadership orientation was perceived as the preferred orientation of the respondents' leaders in all sectors, except rail infrastructure. Leaders working in the oil and gas industry scored the Relation leadership orientation the lowest of all sectors (*M*=1.06 *SD*=1.05), whereas the rail infrastructure sector leaders were at the other end of the spectrum; they are perceived as preferably Relation-oriented, scoring highest of all sectors (*M*=1.59 *SD*=1.06). It is not surprising that the employees in this sector score lowest on the Dominance leadership orientation (*M*=-1.09 *SD*=1.02). Employees in the tank storage sector show the opposite perception of Dominance as a leadership orientation; although still somewhat below 'neutral', in relation to the other business sectors the tank storage sector reports the highest presence of dominant leadership (*M*=tank -0.48 *SD*=1.36). The highest score for Production leadership orientation was returned by the general infrastructure sector (*M*=1.35 *SD*=1.06) and the respondents in the oil and gas industry report the lowest score (*M*=0.80 *SD*=1.12). These data are graphically presented in Section 15.6.1.2.

8.2.2 *Risk Reduction Capacity*

8.2.2.1 Risk Reduction Capacity: General mean scores

On average, employees perceive the different levels of the five risk reduction phases, and *close to agree* that people on the work floor recognise safety risks in their working environment (*M*=1.65 *SD*=1.29). The scores by respondents regarding the Ability of people on the work floor to intervene when risks were recognised were somewhat less (*M*=1.40 *SD*=1.28). Their scores for Motivation to intervene were between these two risk reduction phases (*M*=1.58 *SD*=1.31). Scores for Courage to intervene were somewhat lower than for Motivation (*M*=1.36, *SD*=1.41). Timely Action to solve safety risks scored lowest, but the respondents scored *somewhat agree* slightly higher for this risk reduction phase (*M*=1.31, *SD*=1.45). The Recognition and Motivation risk reduction phase scores are thus relatively high, and Action scores relatively low. These data are graphically presented in Section 15.6.2.1.

8.2.2.2 Risk Reduction Capacity: Mean scores per business sector

This survey question was answered by all 3332 respondents. Due to the different natures of the various business sectors in this research, there are also differences between the mean scores for the risk reduction profiles in these sectors but there are also similarities.

Our first observation is that the respondents in all sectors, except general infrastructure, score the Recognition and Motivation risk reduction phases most highly in their respective sectors. The respondents working in the general infrastructure sector ranked the Recognition risk reduction phase first, and Ability second. The respondents working in the process industry, oil and gas sector, and general infrastructure all ranked the Action risk reduction phase third. The other sectors, tank storage, hospitals, rail infrastructure and other, ranked Action lowest of all risk reduction phases. Respondents in the tank storage sector judged Courage (M=1.61 SD=1.43) as relatively high, where the general infrastructure sector ranked it lowest (M=1.03 SD=1.49).

The relatively overall high scores from the respondents in the oil and gas industry are of interest, with Recognition (M=1.86, SD=1.21) as the top scoring risk reduction phase of all sectors. The respondents working in the oil and gas industry also gave a relatively high score for Action (M=1.46, SD=1.35). The oil and gas sector thus seems to recognise *and* remedy risks more effectively than other sectors. This might be explained by the fact that most of the respondents in that sector work *and* live 24 hours per day on isolated offshore platforms, surrounded by open sea, where the risk of a safety incident is the main safety threat, and the workers themselves are the potential victims of these safety incidents when risks are not recognised and remain unremedied. These data are graphically presented in Section 15.6.2.2.

8.2.3 *Safety*

8.2.3.1 Safety: General mean scores

In the survey general employees were asked to respond to statements indicating their perceptions about the organisation's recent Event History (statement used: "In the area of safety, a great deal went wrong within my organisation in the past year."), about their present Sense of Safety (statement used: "I feel safe in my organisation.") and about their view on the future (statement: "The risk of an accident is real within my organisation.").

The research data shows that with respect to Event History the respondents, on average, *somewhat disagree* with the statement that 'a great deal went wrong in the area of safety' (M=-1.14 SD=1.51). The respondents indicate that, on average, that they feel safe in the present (M=1.91, SD=1.25). On average, scoring between *neutral* and *somewhat agree* (M=0.74 SD=1.76), they not perceive potential safety risks as a real threat. These data are graphically presented in Section 15.6.3.1.

NOTE: The safety of organisations was not investigated during the early phase of this online prospective survey, because it was necessary to add the 'safety' node to the Safety Leadership Model following the pilot survey analysis. This meant that only 2006 respondents were offered the improved survey questionnaire which included statements with respect to 'safety.'

8.2.3.2 Safety: Mean scores per business sector

This survey question was by answered by 2005 respondents. We observed some interesting scores with respect to Safety. At first both the hospital and the oil and gas sectors showed relatively high scores, close to *neutral,* for the 'Event History' variable (respectively M=-0.38, SD=1.57 and M=-0.29, SD=1.58), indicating that the respondents in these sectors considered that, safety-wise, a great deal went wrong in their organisation over the past year. This meant these sectors scored well above the mean for this variable (M=-1.14, corresponding with: *somewhat disagree*). Remarkably the tank storage and rail infrastructure sectors showed the opposite; both sectors scored lower than *somewhat disagree* (respectively M=-1.29, SD=1.51 and M=-1.50, SD=1.31).

The way in which respondents experienced their present individual Sense of Safety was closely connected to their scores for Event History; in sectors where less went wrong last year (i.e., tank storage, the process industry, and both general and rail infrastructure), the respondents scored relatively highly for their Sense of Safety; above *agree*. In the sectors with relatively high scores for Event History (i.e., hospitals and oil and gas), the respondents indicated feeling less safe; around *somewhat agree* (respectively M=0.92, SD=1.52 and M=1.26, SD=1.35). With respect to perceptions of the potential risk of accidents, all sectors except the 'other' group (M=1.35, SD=1.50) indicated scores lower than *somewhat agree* (M=1.00), resulting in a mean score of 0.74 (SD=1.76). The estimate by the rail infrastructure sector, which was close to *neutral*, was exceptionally low (M=0.42, SD=1.89). These data are graphically presented in Section 15.6.3.2.

8.2.4 *Summary*

In this section we summarise the mean scores as presented in the previous sections.

Safety Leadership orientations

As general outcomes concerning Safety Leadership orientations, we noted that the entire group of respondents indicated that they 'somewhat agree' that their leaders show that, in order of scores, they are Process-, Relation- and Production-oriented, and they 'somewhat disagree' that their leaders show Dominance-oriented behaviours. We see a similar pattern in all business sectors with respect to the outcomes concerning Safety Leadership orientations distinguished by business sectors: 'somewhat agreeing' with Process-, Relation- and Production orientation, and 'somewhat disagreeing' with Dominance. The rail infrastructure stands out, with the highest score for Relation orientation and lowest score for Dominance orientation. The process industry stands out with the highest score for Process orientation.

Risk Reduction Capacity

The entire group of respondents scored the Recognition of risks as the highest risk reduction phase, followed closely by Motivation. Action was the lowest scoring risk reduction phase. In the individual business sectors the oil and gas sector stands out with the highest scores for Recognition and Action. In the tank storage sector Motivation and Courage scored highest, and Action was seen as a relatively weak risk reduction phase. This was also true for the process industry, which, unexpectedly, gave relatively low scores for all risk reduction phases. The rail infrastructure sector gave the highest score for Ability.

Safety

In general, the respondents indicated that they 'somewhat disagree' with the statement that 'a great deal went wrong in the past year.' The entire group returned a positive 'agree' score for Sense of Safety. They were less sure about the Risk Potential in their organisation; they scored this between 'neutral' and 'somewhat agree.' The outcomes for each business sector were very interesting. There was an understandably clear relationship between the occurrence of incidents (indicated by scores for 'a great deal went wrong in the past year') and the Sense of Safety. Respondents working in the hospital and oil and gas sectors indicated a relatively high level of 'things going wrong' (read: incidents) and simultaneously a relatively low Sense of Safety. All other sectors reported much lower levels of incidents and much higher senses of safety.

In this section we presented the responses as acquired from general employees in terms of the general mean scores of the Safety Leadership orientations of their direct leaders, their organisation's risk reduction capacities and their individual perceptions about safety. We showed these parameters per business sector, for Safety Leadership orientations, Risk Reduction Capacity and Safety. In addition to the analyses of these data, we also organisation the mean scores related to some additional moderator variables (hierarchical positions, working for certain supervisors, vocational experience, age and major incident experience). The results of these analyses are presented below.

8.3 Outcomes by additional moderator variables

8.3.1 *Summary*

In the previous section we presented the general mean scores and the mean scores per business sector, for Safety Leadership orientations, Risk Reduction Capacity and Safety. In this section we summarise the results for five additional moderator variables: gender of supervisors, hierarchical position, age, vocational experience and incident history.

Safety Leadership

The analysis of moderator variables revealed that in general leaders are Relation- and Process-oriented, followed by Production-oriented leaders. The respondents clearly encountered Dominance-oriented leaders less often. The same picture was seen concerning the gender of supervisors, hierarchical position and vocational experience. Differentiation by age results in a different order; respondents under 31 years old consider their leaders predominantly Production-oriented, followed by Process-, Relation- and (clearly less) Dominance-oriented leaders.

Where safety incident history is concerned, there was a difference between people who had been victims of an incident, or had witnessed a major incident, and respondents who had experienced neither. Victims report that their leaders primarily show Relation-oriented behaviours, followed by Process-, Production- and (clearly less) Dominance-oriented leaders. Witnesses report that their leaders primarily demonstrated Process-oriented behaviours, followed by Relation-, Production- and (clearly less) Dominance-oriented leaders. Respondents who had experienced neither reported equal scores for Relation- and Process-oriented leaders, followed by Relation-, Production- and (clearly less) Dominance-oriented leaders.

Risk Reduction Capacity

Risk reduction phases differentiated by the gender of supervisors show that people working for women gave a lower score for Recognition of risks and remedial Action, but better scores than the followers of male leaders for Ability to intervene, Motivation and Courage to intervene. There were interesting differences in the perceptions of respondents in different hierarchical positions. Directors were clearly the most positive group, followed by senior staff (senior staff members without hierarchical authority). Both groups perceived risks as relatively well recognised at the shop floor level, and that remedial Action is relatively well taken, however the directors scored Courage to intervene as the lowest risk reduction phase. Management returned a similar pattern, but stands out for their relatively low scores for Courage to intervene. Supervisors and support staff followed a similar pattern. Operational staff showed that they were not content about the execution of remedial Actions by giving the lowest scores of all.

Evaluation of Risk Reduction Capacity differentiated by age offered one clear indication: the older the respondents, the better they perceived Risk Reduction Capacity. There was a similar pattern in the evaluations differentiated by vocational experience, although the juniors were somewhat more positive in the first five years where Recognition of risks, Ability to intervene and remedial Action taken were concerned. After five years these perceptions had fallen.

There were some interesting differences where the survey output data was differentiated according to safety incident history. Compared with the other response groups, the victims of incidents considered there to be a relatively high Recognition of risks, Motivation and Courage to intervene, but were not convinced about the Action to intervene risk reduction phase. This also applied for the group with no safety incident experience (neither victim nor witness). Interesting enough, this group scored lowest of all.

Safety

Respondents of both genders scored Event History almost identically where the output data was differentiated by gender. The scores on Sense of Safety indicated that people working for male supervisors feel safer than their colleagues working for female supervisors. People working for female supervisors saw fewer future potential risks than their colleagues working for men.

Evaluations differentiated by hierarchical positions demonstrate clear differences; directors, supervisors, support staff and senior staff (senior employees without hierarchical authority) report the lowest Event History, indicating that they consider the incident rate relatively low. Management and operational staff are slightly less positive about incidents records. Directors are most confident that their organisation is safe where their Sense of Safety is concerned, closely followed by their managers and senior staff. Supervisors and support staff also feel relatively safe, but people in operations are less content with the level of safety.

The survey responses show that older people perceived less impact from incidents. The older respondents also felt safer than the younger respondents. Future risk judgement differed according to age category; the group between 31 and 40 years of age saw more potential risk than the others, and the oldest group (51–67 years) saw the lowest potential risk in their organisation.

When differentiated by vocational experience, the least and the most experienced groups perceived a relatively low number of safety incidents. The least experienced group (0–5 years of experience) felt safest, and scored Sense of Safety highest. The middle category, people with 11–30 years of experience, perceived future potential risks as highest; the group with 5–10 years of experience perceived potential risk as lowest.

When differentiated according to individual incident history, ex-victims and the witnesses of major incidents scored the safety characteristic in the same way. Respondents who reported no incident history at all scored Event History lowest, Sense of Safety highest, and expectation concerning Risk Potential lowest.

8.3.1.1 Mean scores by gender of supervisor

In the following sections we present the respondents' mean scores in relation to the Safety Leadership orientations of their direct leaders, Risk Reduction Capacity and Safety, according to the gender of their direct supervisors.

Of a total population of 3332, 3298 respondents completed a question designed to reveal the specific gender distribution of their direct supervisors. This survey question was answered by employees working for 2578 men and 720 women (77% men and 22% women). These numbers are presented in Table 13 below.

	Frequency	Percent
Male	2578	77.4
Female	720	21.6
Total	3298	99.0
Missing	34	1.0
Total	3332	100.0

TABLE 13 Gender of respondents' direct supervisors

Safety Leadership orientations by gender of direct supervisors

This part of the survey outcomes shows the scores for Safety Leadership, differentiated by respondents working for female and male direct supervisors. The data shows slight differences in the scores of people working for female supervisors and people working for male supervisors. People working for female supervisors scored Relation- and Production-oriented leadership behaviours more highly (respectively *M*=1.51, *SD*=1.17 and *M*=1.20, *SD*=1.22) than their colleagues working for male supervisors (respectively *M*=1.29, *SD*=1.19 and *M*=1.13, *SD*=1.22). People working for women perceived their supervisors as less dominant (*M*=-0.88, *SD*=1.04) than people working for men (*M*=-0.80, *SD*=1.16). The data generated by the general employees suggests that female supervisors show more Relation- and Production-oriented behaviours, and are considered less Dominance-oriented.

Risk Reduction Capacity by gender of supervisors

The scores for the five risk reduction phases as generated by respondents working for male and female direct supervisors were also split in order to identify possible differences in the mean scores. This survey question was answered by 2578 male and 719 female respondents.

The scores related to the individual risk reduction phases as reported by male and female respondents are very similar and follow the same order of precedence. The minor differences observed are that respondents working for male direct supervisors scored the Recognition and Action risk reduction phases (respectively *M*=1.68 *SD*=1.29 and *M*=1.35 *SD*=1.45) slightly higher than the respondents working for female supervisors; the scores for the latter were respectively *M*=1.58 *SD*=1.28 and *M*=1.24 *SD*=1.43. the opposite was true for the other three risk reduction phases, Ability, Motivation and Courage: the scores of people working for female supervisors (respectively *M*=1.41 *SD*=1.23, *M*=1.64 *SD*=1.25 and *M*=1.40 *SD*=1.35) slightly exceeded the scores by their colleagues working for male supervisors (respectively *M*=1.39 *SD*=1.30, *M*=1.57 *SD*=1.33 and *M*=1.35 *SD*=1.43).

The practical implications of the observed differences between the scores reported from male and female respondents are negligible.

Safety by gender of direct supervisors

The scores for the three safety characteristics as generated by respondents working for male and female direct supervisors were differentiated in order to identify possible differences in the mean scores. This survey question was answered by 1640 male and 364 female respondents. We observed that the scores related to individual safety by respondents working for male supervisors, and for female supervisors are very similar and follow the same approximate pattern for Event History, Sense of Safety and potential future risk. The only notable difference was that respondents working for male direct supervisors were slightly more positive concerning their Sense of Safety than people working for female supervisors (respectively M=1.96, SD=1.20 and M=1.70, SD=1.44).

These data are graphically presented in Section 15.7.1.

8.3.1.2 Mean scores by hierarchical position

We also considered the possible differences in individual perceptions by people holding different hierarchical positions. We therefore analyzed the scores given according to the positions of directors, managers, supervisors, support staff, operational staff and senior staff (the latter position refers to business sectors where people hold senior positions without hierarchical authority).

Hierarchical positions of respondents

The valid respondents held six different hierarchical position levels: directors/board members, managers, supervisors, support staff, senior staff and operational staff. Out of a total population of 3332, 3317 respondents completed this questionnaire question. Within the group of general employees, operational staff represented 46% of the respondents, supervisors 20%, support staff (predominantly members of quality and safety departments) 17%, category managers 10%, senior staff 5%, and directors/board members 1%.

The results of the data analyses regarding the perceptions of the respondents regarding the Safety Leadership Orientations of their direct leaders, Risk Reduction Capacity and Safety are presented below.

Safety Leadership by hierarchical positions

This survey question was answered by 3317 respondents. There were some interesting details in the position-specific survey data. First, the outcomes show that, compared to respondents in other positions, directors perceive the Relation-, Process and Production leadership orientations most positively; this group scores highest of all respondents (respectively M=1.69, SD=1.03, M=1.56, SD=1.13 and M=1.48, SD=1.02). Senior staff follows closely for these leadership orientations (respectively M=1.54, SD=0.99, M=1.55, SD=0.89 and M=1.48, SD=1.19). Managerial respondents reported Process as the primary leadership orientation (M=1.55, SD=1.01). The same was true for supervisors (M=1.42, SD=1.02). An obvious difference can be seen when comparing the scores by directors, and their managers and supervisors: there is a gap between the scores of directors (M=1.48, SD=1.02) and those of managers (*M*=1.21, *SD*=1.19) and supervisors (*M*=1.09, *SD*=1.20). Apparently, directors perceive the behaviour of the people they report to (boards of directors, shareholders and the like) as primarily Relation- and Process-oriented. The scores by senior staff are similar to those by the directors. It is interesting to see that senior staff score the Dominance leadership orientation lowest of all positions (*M*=-0.96, *SD*=1.11).

Operational staff, as the group primarily exposed to operational safety hazards, score lowest of all positions for Relation-, Process- and Production-oriented leadership (respectively *M*=1.24, *SD*=1.30, *M*=1.21, *SD*=1.14 and *M*=1.05, *SD*=1.19), and score the Dominance leadership orientation highest (*M*=-0.78, *SD*=1.18); and their supervisors follow suit by (*M*=-0.79, *SD*=1.10).

Risk Reduction Capacity by hierarchical position

This survey question was answered by 3311 respondents. We observed that the respondents in all positions considered Recognition as the most controlled of the five risk reduction phases.

The very high degree of confidence (*M*=2.24, *SD*=0.92) shown by the directors, closely followed by senior staff, is notable (*M*=2.03, *SD*=1.01). Compared with the other four positions, the respondents in these two most senior positions perceive all risk reduction phases as the best controlled. Another interesting observation is that respondents in all positions indicate the Motivation risk reduction phase as second best controlled.

Management considered the Courage risk reduction phase (*M*=1.01, *SD*=1.45) as least controlled of all respondents, and demonstrated relatively high confidence in the Action phase (*M*=1.39, *SD*=1.32). A relatively high confidence in Action is supported by supervisors (*M*=1.50, *SD*=1.32) and support staff (*M*=1.27, *SD*=1.38). This was not true for operational staff, who considered Action (*M*=1.18, *SD*=1.56) the least controlled of all, and also the least controlled of all positions.

Safety by hierarchical positions

Safety represents the respondents' specific safety-related perceptions. This reflects the past through the respondents' experiences of *safety events*, the present through the respondents' *sense of the actual safety* for the primary process concerned, and the future through the respondents' impressions of the likelihood of operational disturbances, referred to as the *Risk Potential.* This survey question was answered by 2000 respondents. We observed that directors and senior staff experienced actual safety events as relatively infrequent (respectively *M*=-1.32, *SD*=1.45 and *M*=-1.55, *SD*=1.28). Respondents in these positions also reported that their Sense of Safety was relatively high; directors *M*=2.55, *SD*=0.51 and senior staff *M*=2.17, *SD*=1.11. Management also shows a relatively high level of confidence in Sense of Safety (*M*=2.28, *SD*=0.92), however this group had experienced a somewhat higher level of actual safety events than reported by the directors and senior staff (*M*=-1.02, *SD*=1.43).

Individual safety as reported by operational staff is of special interest. These respondents reported the highest level of actual safety events (*M*=-0.99, *SD*=1.60), and the lowest Sense of Safety (*M*=1.68, *SD*=1.38).

Directors reported a relatively high level of Risk Potential in their analyzed (*M*=1.30, *SD*=1.66), whereas senior staff perceived this characteristic as relatively low (*M*=-0.45, *SD*=1.89), and the respondents in other positions reported values between *M*=-0.71, *SD*=1.74 and *M*=-0.91, *SD*=1.58.

These data are graphically presented in Section 15.7.2.

8.3.1.3 Mean scores by age

The different moderator variables analyzed were chosen because we considered them possibly of influence with respect to the survey outcomes. In this research, age is considered a relevant variable where it concerns the safety-related perceptions of individuals. Of a total population of 3332, 3319 general employees informed us about their age. We divided these general employees into four age groups: age up to 30 (n=352), age between 31 and 40 (n=737), age between 41 and 50 (n=1001), and age between 51 and 67 (n=1229). The following sections show the results regarding their perceptions of the Safety Leadership orientations of their direct leaders, Risk Reduction Capacity and Safety, differentiated by the age of the respondents.

Safety Leadership by age

This survey question was answered by 3319 respondents. There were very similar perceptions regarding Relation (scores between *M*=1.29, *SD*=1.13 and *M*=1.36, *SD*=1.24) and Process leadership orientations (scores between *M*=1.31, *SD*=1.02 and *M*=1.38, *SD*=1.10), indicating that age does not make a difference to views on these two leadership orientations. The youngest group (<31 of age) recognised Production-oriented leaders more often (*M*=1.32, *SD*=1.11), than their older colleagues (respectively: age 31–40 *M*=1.13, *SD*=1.19, age 41–50 *M*=1.11, *SD*=1.22 and age 51–67 *M*=1.11, *SD*=1.26). The youngest group also distinguished itself in their perceptions of the Dominance leadership orientation. Respondents aged <31 report more Dominance (*M*=-0.62, *SD*=1.03) than their older colleagues, who experienced less Dominance as they grew older (respectively: age 31–40 *M*=-0.74, *SD*=1.06, age 41–50 *M*=-0.85, *SD*=1.11 and age 51–67 *M*=-0.88, *SD*=1.20).

Risk Reduction Capacity by age

We observed some interesting variations between the different age groups concerning their insights into Risk Reduction Capacity. The confidence in Recognition of safety risks increases with age. Respondents younger than 31 years of age scored this lowest (*M*=1.45, *SD*=1.34), and the other scores were as follows: 31–40 age group (*M*=1.53, *SD*=1.27), the 41–50 age group (*M*=1.68, *SD*=1.29) and the oldest age group, 51–67 (*M*=1.77, *SD*=1.25). The other four risk reduction phases showed a similar pattern, with one exception: respondents aged between 31 and 40 considered the Ability to intervene lowest of all groups (*M*=1.30, *SD*=1.28) (age group <31 (*M*=1.40, *SD*=1.25), age group 41–50 (*M*=1.41, *SD*=1.29) and the oldest age group, 51–67 (*M*=1.46, *SD*=1.27)).

Safety by age

The safety-related questions concerning the respondents' views on Event History returned interesting outcomes from the different age groups of respondents. The younger than 31 age group (*M*=-0.79, *SD*=1.56) were more concerned about the incident history of their analyzed than their older colleagues between ages 31–40 (*M*=-0.92, *SD*=1.50), the 41–50 age group (*M*=-1.16, *SD*=1.52) and the oldest age group, 51–67 (*M*=-1.36, *SD*=1.46). The youngest age group (<31) also returned the lowest score for their present Sense of Safety (*M*=1.72, *SD*=1.41). Their older colleagues judged the safety of the analyzed somewhat higher, and reported the following, relatively similar scores; the 31–40 age group (*M*=1.90, *SD*=1.22), the 41–50 age group (*M*=1.93, *SD*=1.21) and the oldest age group, 51–67 (*M*=1.96, *SD*=1.22). The oldest age group (51–67) returned the lowest score for future potential risks (*M*=0.66, *SD*=1.80). Their younger colleagues perceived this potential somewhat higher; they scored it as follows: the <31 age group (*M*=0.67, *SD*=1.69), the 31–40 age group (*M*=0.82, *SD*=1.69) and the 41–50 age group (*M*=0.79, *SD*=1.77).

These data are graphically presented in Section 15.7.3.

8.3.1.4 Mean scores by vocational experience

We considered the vocational competence of the people involved as influential in risk reduction, and explain 'competence' according to the combined results for vocational knowledge, skills and experience. We therefore included vocational experience in this online prospective survey questionnaire. Of a population of 3332, 3319 general employees informed us about their vocational experience. We divided these general employees into five time periods: <5 years of experience (n=546), 5–10 years of experience (n=668), 11–20 years of experience (n=883), 20–30 years of experience (n=674), and over 30 years of experience (n=548).

In the following sections we present the perceptions of respondents have regarding the leadership orientations of their direct leaders, Risk Reduction Capacity and Safety, according to their vocational experience (in terms of years of experience in the business sector in which they are actually working).

Safety Leadership by vocational experience

This survey question was completed by 3319 respondents. We observed that respondents with relatively little vocational experience (0–5 years) clearly considered their direct supervisors as mainly Relation-oriented leaders (*M*=1.47, *SD*=1.08). In order of perceptions, this group considered their leaders as Process- (*M*=1.39, *SD*=1.02), Production- (*M*=1.27, *SD*=1.15) and Dominance-oriented (*M*=-0.80, *SD*=1.0). The respondents with 5–10 years of experience showed a similar trend, starting with a score of *M*=1.36, *SD*=1.14 for Relation-oriented leaders, gradually decreasing to *M*=-0.85, *SD*=1.09 for Dominance-oriented leaders. After 10 years of experience the respondents' views changed in that respondents with 11–50 years of experience reported that most leaders were Process-oriented (*M*=1.31, *SD*=1.09). Relation-oriented leaders (*M*=1.25, *SD*=1.20) were placed second in order. As in the groups with little vocational experience, Production- (M=1.11, SD=1.21) and Dominance-oriented (M=-0.79, SD=1.16) leaders were less often reported. Respondents with 31–50 years of experience perceived their leaders as equally Relation- (M=1.39, SD=1.24) and Process-oriented (M=1.39, SD=1.12). Compared with all these groups, the most senior respondents perceived Production (M=1.11, SD=1.21) and Dominance (M=1.11, SD=1.21) as least present.

Risk Reduction Capacity by vocational experience

This survey question was completed by 3311 respondents. With respect to Risk Reduction Capacity, we observed that the most experienced respondents considered risk reduction most effectively controlled. This group, with 31–50 years of vocational experience, returned the following scores: Recognition M=1.85, SD=1.27, Ability M=1.54, SD=1.25, Motivation M=1.84, SD=1.26, Courage M=1.66, SD=1.35 and Action M=1.49, SD=1.45. These scores mean that this senior group perceive Recognition and Motivation on the work floor well implemented. Except for the juniors (0–5 years of vocational experience) the other respondents with 5–30 years of experience also scored Recognition and Motivation as the highest scoring risk reduction phases. The juniors scored Ability (M=1.52, SD=1.31) second and Motivation (M=1.46, SD=1.33) third. We also observed the interesting phenomenon that all groups, except the respondents with less than 5 years of experience, indicated that they perceived the Action risk reduction phase as the least controlled of all five phases. Courage was reported as controlled least by respondents with less than 11 years of experience (M=1.26, SD=1.41 and M=1.26, SD=1.43). Respondents with 11- 50 years of experience perceived Courage as better controlled (M=1.32, SD=1.39; M=1.37, SD=1.44; and M=1.66, SD=1.35).

Safety by vocational experience

This survey question was completed by 1999 respondents. The survey outcomes concerning safety, as reported in the five specific categories of vocational experience, show some interesting differentiations between the groups. The most experienced group reported the lowest score of all groups for event History (M=-1.39, SD=1.51). The other four groups reported perceptions between M=1.04, SD=1.53 and M=1.13, SD=1.52. The least experienced (0–5 years) group showed the highest confidence in the level of safety of the analyzed via Sense of Safety (M=2.02, SD=1.23). This confidence decreases, however, when people reach the next level of vocational experience (5–10 years) (M=1.88, SD=1.22), which remains around that level during the following years. How the respondents judge the future is shown by their perceptions of Risk Potential. The group with 5–10 years of experience had the lowest expectations (M=0.62, SD=1.79), the next group (11–20 years) had the highest expectations (M=0.87, SD=1.69), and the other groups expect Risk Potential in levels in between these two extremes.

These data are graphically presented in Section 15.7.4.

8.3.1.5 Mean scores by safety incident history

Involvement in a safety incident, whether as a witness or, even more intensely, as a victim, is an emotional experience, which may affect an individual's perceptions of the context in which they work. We therefore considered 'incident history' a relevant moderator variable in this research. In the following sections we present the effects of safety incident history on the leadership orientations of the participants' direct leaders, Risk Reduction Capacity and Safety.

Safety Leadership by safety incident history

Having experienced an incident with serious consequences, or having been a witness to such incident may have an effect on the way people view the safety risks in their working environment. Our survey shows that 3298 respondents of the population of 3332 general employees replied to this question: 233 respondents reported having been the victim of a serious accident, 1293 respondents had witnessed a serious accident and 1772 respondents had never experienced nor witnessed a serious accident.

The survey outcomes show that respondents who have been the victims of a serious safety incident consider their leaders predominantly Relation-oriented (*M*=1.35, *SD*=1.33), then Process-oriented (*M*=1.25, *SD*=1.14) and then Production-oriented (*M*=1.12, *SD*=1.29). According to these victim-respondents Dominance-oriented direct leaders are rare (*M*=-0.78, *SD*=1.25). Respondents who had witnessed major incident(s) reported that their leaders show predominantly Process-oriented behaviours (*M*=1.34, *SD*=1.23). These respondents reported that the next group of direct leaders was Relation-oriented (*M*=1.29, *SD*=1.23). Witness respondents scored Production-oriented leaders (*M*=1.11, *SD*=1.28) and Dominance-oriented leaders (*M*=-0.75, *SD*=1.17) in the same order as the victim-oriented leaders. Respondents who had not been involved in safety incidents, as victim either or witness, described the leadership orientations of their direct leaders somewhat more istinctly than the other categories of respondents (Relation *M*=1.37, *SD*=1.14, Process *M*=1.37, *SD*=1.02, Production *M*=1.17, *SD*=1.17 and Dominance *M*=-0.87, *SD*=1.09).

Risk Reduction Capacity by safety incident history

Having experienced an incident with serious consequences, or having been a witness to such an event may have an effect on the way people view the safety risks in their working environment. Our survey shows that 3298 respondents of the population of 3332 general employees replied to this question: 232 respondents reported having been the victim of a serious accident, 1292 respondents had witnessed a serious accident, and 1767 respondents had never experienced or witnessed a serious accident. The analysis showed that respondents who have reported being victims of safety incidents have most confidence of all groups, with respect to four of the five risk reduction phases; only the Action phase scored as low as for the respondents who had not been involved (as either victim or witness) in safety incidents. We also observed that all three groups showed a similar trend where scores concerning the Risk Reduction Capacity were concerned.

Safety by safety incident history

Having experienced an accident with serious consequences, or having been a witness to such an event may have an effect on the way people view the state of safety in their working environment. Our survey shows that 2004 respondents of the population of 3332 general employees replied to this question. 140 respondents noted having been the victim of a serious accident, 821 respondents had witnessed a serious accident, and 1043 respondents had never experienced or witnessed a serious accident. This analysis shows that safety clearly differs between the three categories of respondents. Respondents who had been the victims of safety incidents gave a medium score for Event History (*M*=-1.12, *SD*=1.53), whereas witnesses perceived more safety incidents having occurred (*M*=1.0, *SD*=1.56) and respondents who had not been involved in safety incidents at all reported the least number of incidents (*M*=1.27, *SD*=1.46). A Sense of Safety was lowest for respondents who had been victims (*M*=1.73, *SD*=1.34). Witness respondents were slightly more positive about their sense of Safety (*M*=1.86, *SD*=1.27) and respondents who had not been involved in safety incidents at all were most positive about their Sense of Safety (*M*=1.97, *SD*=1.21). Risk Potential demonstrated the opposite trend with respect to perceptions of the future; victims scored the possibility of future risks highest (*M*=1.05, *SD*=1.71), witnesses scored this option at an intermediate level (*M*=0.96, *SD*=1.67) and people who had not been involved in safety incidents in any way scored Risk Potential lowest (*M*=0.52, *SD*=1.80).

These data are graphically presented in Section 15.7.5.

Having determined the mean scores as presented in the above sections, we reached the concluding analysis stage; testing the specific relationships (path analysis) between the three nodes of the Safety Leadership Model (Safety Leadership, Risk Reduction Capacity and Safety). We thus analyzed the acquired survey data via Structural Equation Modelling (SEM). The results of this process are presented in the following sections.

8.4 Structural Equation Modelling (SEM) path analysis

The Safety Leadership Model Version III (Figure 26), as presented in Section 7.5, served as the basic structure for this SEM path analysis. In this model Risk Reduction Capacity is considered the mediating factor between Safety Leadership and Safety. The Recognition, Ability, Motivation, Courage and Action risk reduction phases are considered mutually independent entities. Due to this independence and the different characteristics of the risk reduction phases, five separate SEM path analyses were performed; one analysis for each risk reduction phase. In these path analyses the four leadership orientations (Production, Process, Relation and Dominance) are considered as independent *predictors*, the risk reduction phases are considered *mediators* and the three safety characteristics (Event History, Sense of Safety and Risk Potential) are considered dependent *outcomes*.

Structure of presentation

The presentation of the SEM path analysis results follows the sequence of the five phases of the Risk Reduction Cycle (Recognition, Ability, Motivation, Courage and Action). Each section consists of two sub-sections: the analysis results (tables and figures) and the interpretation of results (text). In the 'Analysis results' sections the results of the subject path analysis are presented in a table, and in a figure showing the mapped analysis results.

Analysis results (tables)

On the third line of the tables, we show the explained variances between the applicable mediating risk reduction phase and the three safety characteristics (Event History, Sense of Safety and Risk Potential). The effects of two different path analyses, one showing the mediated, and one showing the non-mediated (or direct), effects of the four leadership orientations on the three safety characteristics, are displayed, working down from the sixth line to the bottom of the tables (line 13).

The powers of the displayed effects are expressed in standardised regression coefficients.[1] This means that a higher absolute value represents a stronger effect, and vice versa. Positive effects are shown as positive numbers, and negative effects are shown as negative numbers. Only the significant ($p < .05$) and the highly significant ($p < .01$) paths are considered in this analysis.

Classification of identified values

In order to evaluate the statistical power of the identified correlation levels, we refer to a hierarchical taxonomy of variables to produce empirical effect size benchmarks, as developed by Bosco et al.[2] Their Correlational Effect Size Benchmarks table (Appendix 15.4) refers to statistical power criteria as published by Cohen[3] in terms of uncorrected effect size ($|r|$). The criteria as published by Bosco et al. conclude that $|r|$ values between .24 and .50 are classified as a 'medium' or 'moderate' effect size. We used this effect size classification as guidance during the interpretation of the correlations as described below.

Analysis results (figures)

The analysis results are graphically presented below the tables. These figures show the four leadership orientations at the top, the applicable risk reduction phase below, and the three safety characteristics at the bottom. Arrows show the directions and the specific effect sizes, as given in the tables. Each arrow is accompanied by a number indicating the applicable effect size.

1 The numbers indicating standardised regression coefficients represent the change rate in response, in terms of one standard deviation (SD) change in a predictor.

2 Bosco, Aguinis, Singh, Field and Pierce (2015), p. 433.

3 Cohen (2013)

Explanations

We explain the analysis results after each section, in a sub-section: 'Explanation of effects per leadership orientation.' We explain the specific effects of the applicable risk reduction phase under the same heading.

We give the results of these five SEM path analyses in the next sections.

8.4.1 *Recognition-related effects*

In this section we present the results of the SEM path analysis related to the Recognition risk reduction phase.

Analysis results

The SEM path analysis results for cases where Recognition acts as a mediator between the four leadership orientations and the three safety characteristics are shown in Table 14 below.

Risk reduction phase: RECOGNITION		Event History	Sense of Safety	Risk Potential
Explained variance		.198	.299	.018
Leadership orientation	**Effect**	**Standardised regression coefficient**		
Relation	**Direct**	.34	-	-
	Mediated	.04	-.004	-
Process	**Direct**	-.45	.37	-
	Mediated	-.12	.10	-
Production	**Direct**	.17	-	-
	Mediated	.03	-.03	-
Dominance	**Direct**	.37	-	.23
	Mediated	-	-	

TABLE 14 Leadership effects (mediator: Recognition)

A graphical representation of the standardised regression coefficients as included in the above analysis table is shown in Figure 27 below.

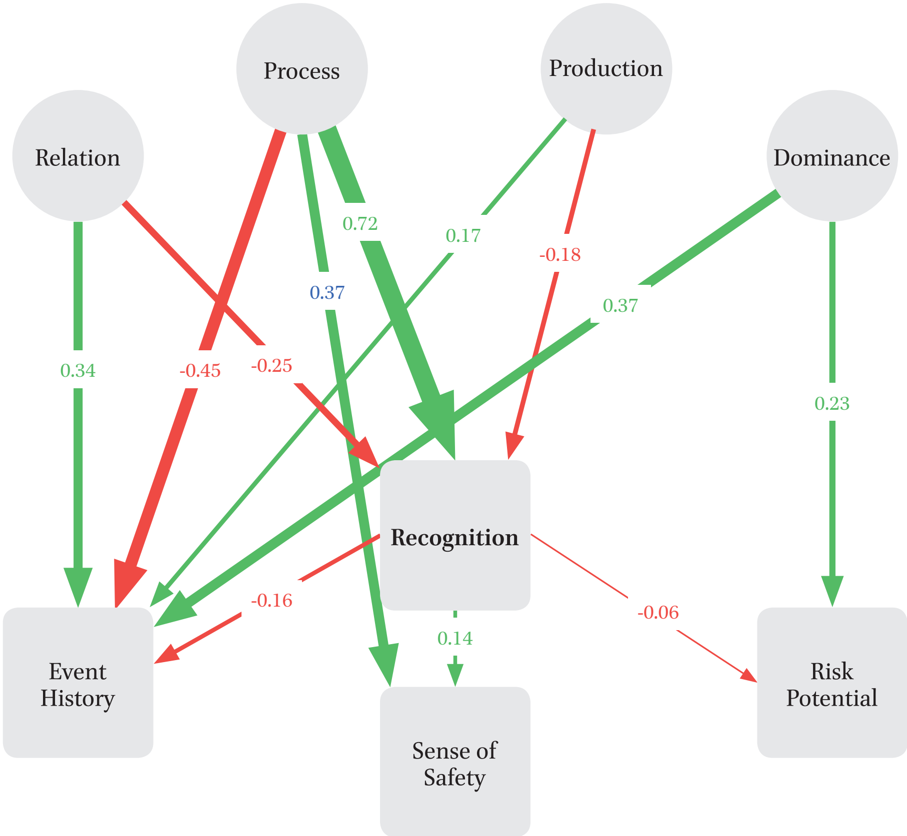


FIGURE 27 Significant effects (mediator: Recognition)

Explanation of effects per leadership orientation

Relation-oriented leaders

We observe that Relation-oriented leaders have a medium-strong positive effect (.34) on the occurrence of safety incidents (shown by the green arrow leading to Event History). A red arrow to Recognition shows us that Relation-oriented leaders have a medium strong reductive effect (-.25) on Recognition, so the more a leader behaves in a Relation-oriented way, the less risks are recognised.

Process-oriented leaders

We see a red arrow in the direction of Event History, concerning Process-oriented leaders, which means that they have a medium strong reducing effect (-.45) on the occurrence of safety incidents. We also note two green arrows, indicating that Process-oriented leaders have a strong positive effect on Recognition (.72), and a medium strong positive effect (.37) on the Sense of Safety of the respondents of this survey.

Production-oriented leaders

Production-oriented leaders have a weakly positive effect (.17) on the occurrence of incidents (shown by the green arrow leading to Event History), and also a weak negative effect (-.18) on Recognition. Leaders behaving in a Production-oriented way thus increase safety incidents and dampen the Recognition of risks.

Dominance-oriented leaders

The green arrow pointing at Event History shows that leaders in this group have a medium strong positive effect (.37) on the occurrence of safety incidents. We also see a green arrow in the direction of Risk Potential, showing a weak Relation (.23) with this safety element, and meaning that the more dominantly leaders behave, the more potential risks are expected.

Mediator's influence

In this analysis we note that the Recognition of risks has a weakly positive effect (.14) on the Sense of Safety (green arrow), a weak negative effect (-.16) on Event History, and a negligible effect (-.06) on Risk Potential (both red arrows).

8.4.2 *Ability-related effects*

In this section we present the results of the SEM path analysis related to the Ability risk reduction phase.

Analysis results

The SEM path analysis results for cases where Ability acts as a mediator between the four leadership orientations and the three safety characteristics are shown in Table 15 below.

Risk reduction phase: ABILITY		**Event History**	**Sense of Safety**	**Risk Potential**
Explained variance		.198	.299	.018
Leadership orientation	**Effect**	**Standardised regression coefficient**		
Relation	**Direct**	.36	-	-
	Mediated	-	-	-
Process	**Direct**	-.47	.39	-
	Mediated	-.09	.08	-
Production	**Direct**	.18	-	-
	Mediated	.03	-.02	-
Dominance	**Direct**	.37	-	.23
	Mediated	-	-	-

TABLE 15 Leadership effects (mediator: Ability)

A graphical representation of the standardised regression coefficients as included in the above analysis table is shown in Figure 28 below.

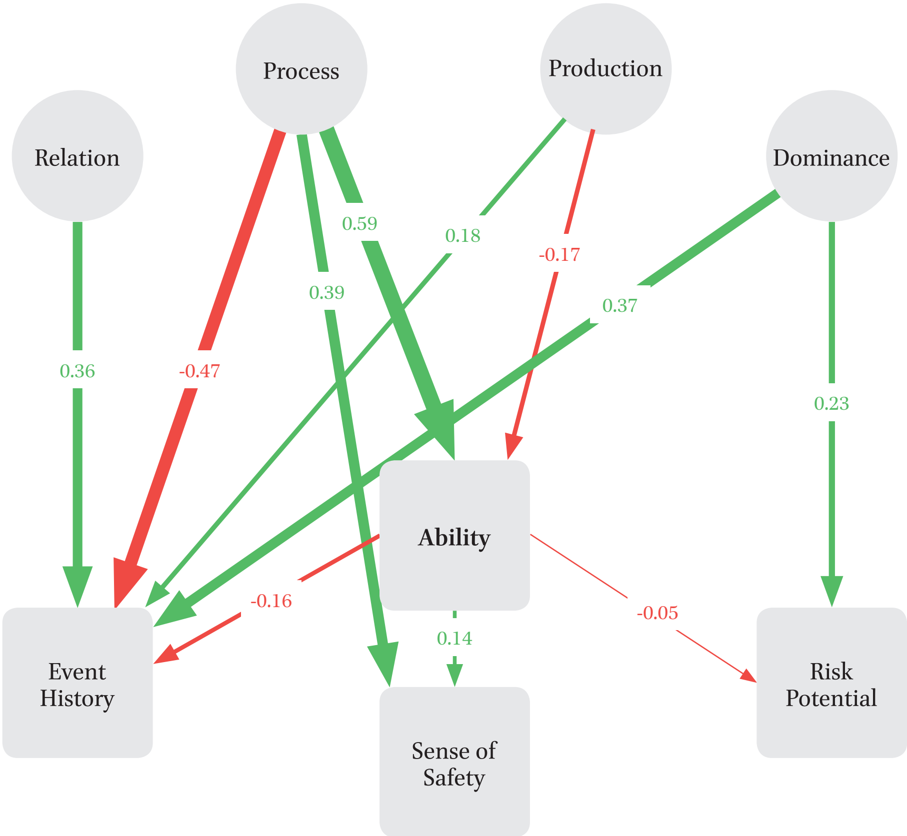


FIGURE 28 Significant effects (mediator: Ability)

Explanation of effects per leadership orientation

Relation-oriented leaders

The green arrow leading to Event History shows that Relation-oriented leaders have a medium-strong positive effect (.36) on the occurrence of safety incidents.

Process-oriented leaders

There is a red arrow in the direction of Event History for Process-oriented leaders, which means that they have a medium-strong effect (-.47) in reducing safety incidents. The two green arrows indicate that Process-oriented leaders have a strong positive effect (.59) on Ability and a medium-strong positive effect (.39) on the Sense of Safety, for the respondents of this survey.

Production-oriented leaders

Production-oriented leaders have a weakly positive effect (.18) on the occurrence of incidents (shown by the green arrow leading to Event History), and also a weakly negative effect (-.17) on Ability. Leaders behaving in a Production-oriented manner thus promote safety incidents and dampen the Ability to intervene.

Dominance-oriented leaders

The green arrow pointing at Event History shows that leaders in this group have medium-strong positive effects (.37) on the occurrence of safety incidents. We also see a green arrow in the direction of Risk Potential, showing a weak Relation (.23) with this safety element, and meaning that the more dominantly leaders behave, the more potential risks are expected.

Mediator's influence

Ability to intervene has a weakly positive effect (.14) on the Sense of Safety (green arrow), a weakly negative effect (-.16) on Event History and a negligible effect (-.05) on Risk Potential (both red arrows).

8.4.3 *Motivation-related effects*

In this section we present the results of the SEM path analysis related to the Motivation risk reduction phase.

Analysis results

The SEM path analysis results for cases where Motivation acts as a mediator between the four leadership orientations and the three safety characteristics are shown Table 16 below.

Risk reduction phase: MOTIVATION		**Event History**	**Sense of Safety**	**Risk Potential**
Explained variance		.189	.287	.018
Leadership orientation	**Effect**	**Standardised regression coefficient**		
Relation	**Direct**	.38	-	-
	Mediated	-	-	-
Process	**Direct**	-.52	.44	-
	Mediated	-.05	.03	-
Production	**Direct**	.19	-	-
	Mediated	-	-	-
Dominance	**Direct**	.37	-	.23
	Mediated	-	-	-

TABLE 16 Leadership effects (mediator: Motivation)

A graphical representation of the standardised regression coefficients as included in the above analysis table is shown in Figure 29 below.

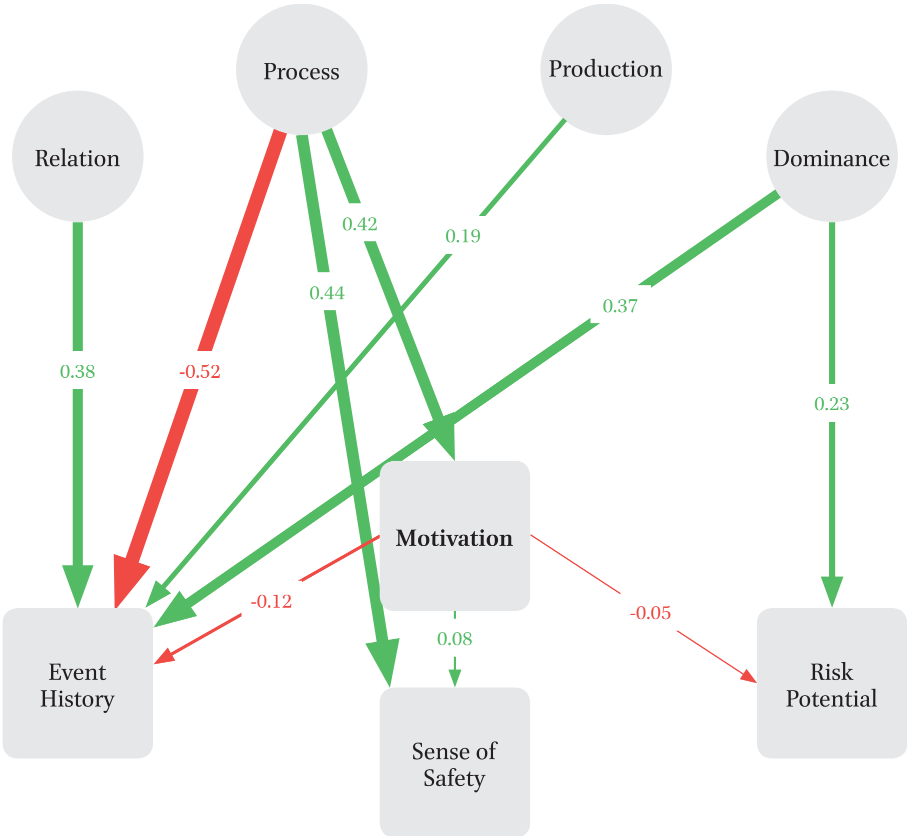


FIGURE 29 Significant effects (mediator: Motivation)

Explanation of effects per leadership orientation

Relation-oriented leaders

The green arrow leading to Event History shows that Relation-oriented leaders have a medium-strong positive effect (.38) on the occurrence of safety incidents.

Process-oriented leaders

Concerning Process-oriented leaders, we see a red arrow in the direction of Event History for Process-oriented leaders, which means that they have a strong reducing effect (-52) on the occurrence of safety incidents. We also observe two green arrows, indicating that Process-oriented leaders have a medium-strong positive effect (.42) on Motivation, and a medium-strong positive effect (.44) on the Sense of Safety of the respondents of in this survey.

Production-oriented leaders

Production-oriented leaders have a weakly positive effect (.19) on the occurrence of incidents (shown by the green arrow leading to Event History).

Dominance-oriented leaders

The green arrow pointing at Event History shows that leaders in this group have a medium-strong positive effect (.37) on the occurrence of safety incidents. We also see a green arrow in the direction of Risk Potential, showing a weak Relation (.23) with this safety element, and meaning that the more dominantly leaders behave, the more potential risks are expected.

Mediator's influence

In this analysis we note that Motivation to intervene has a negligible effect on the Sense of Safety (green arrow), a weak negative effect on Event History and a negligible effect on Risk Potential (both red arrows).

8.4.4 *Courage related effects*

In this section we present the results of the SEM path analysis related to the Courage risk reduction phase.

Analysis results

The SEM path analysis results for cases where Courage acts as a mediator between the four leadership orientations and the three safety characteristics are shown Table 17 below.

Risk reduction phase: COURAGE		Event History	Sense of Safety	Risk Potential
Explained variance		.196	.286	.02
Leadership orientation	**Effect**	**Standardised regression coefficient**		
Relation	**Direct**	.36	-	-
	Mediated	-	-	-
Process	**Direct**	-.47	.43	-
	Mediated	-.09	.04	.04
Production	**Direct**	.18	-	-
	Mediated	-	-	-
Dominance	**Direct**	.38	-	.24
	Mediated	-	-	-

TABLE 17 Leadership effects (mediator: Courage)

A graphical representation of the standardised regression coefficients as included in the above analysis table is shown in Figure 30 below.

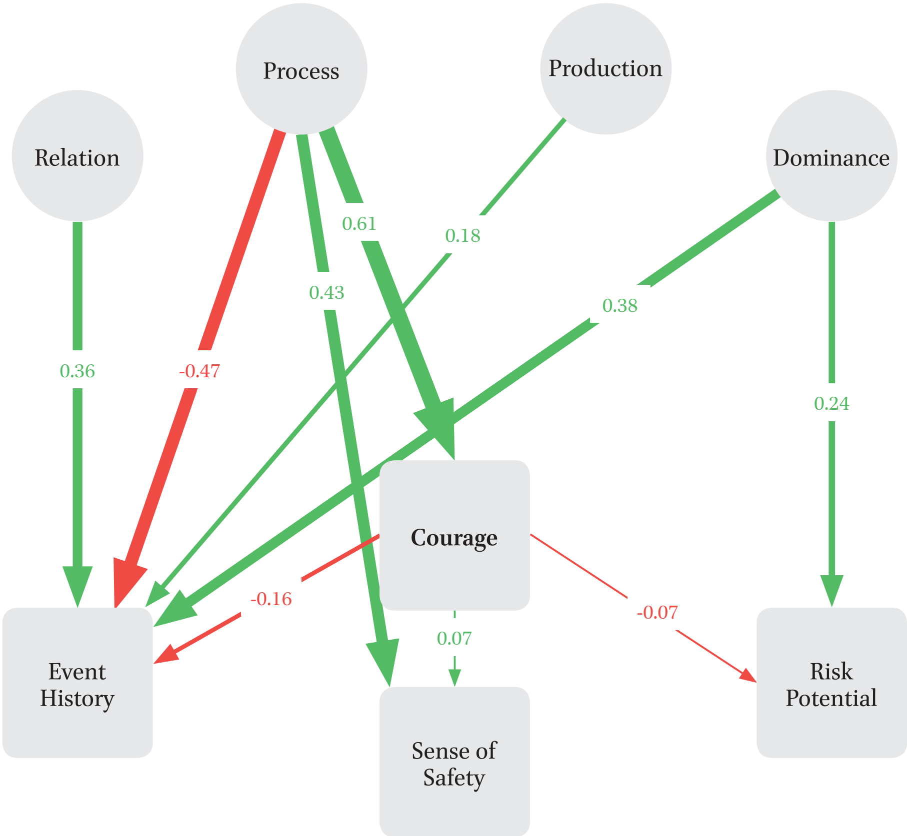


FIGURE 30 Significant effects (mediator: Courage)

Explanation of effects per leadership orientation

Relation-oriented leaders

The green arrow leading to Event History shows that Relation-oriented leaders have a medium-strong positive effect (.36) on the occurrence of safety incidents.

Process-oriented leaders

A red arrow points in the direction of Event History, which means that Process-oriented leaders have a medium-strong reducing effect (-.47) on the occurrence of safety incidents. We also observe two green arrows, indicating that Process-oriented leaders have a strong positive effect (.61) on Courage, and a medium-strong positive effect (.43) on the Sense of Safety for the respondents of this survey.

Production-oriented leaders

Production-oriented leaders have a weakly positive effect (.18) on the occurrence of incidents (shown by the green arrow leading to Event History). Leaders behaving in a Production-oriented manner thus cause safety incidents.

Dominance-oriented leaders

The green arrow pointing at Event History shows that leaders in this group have a medium-strong positive effect (.38) on the occurrence of safety incidents. We also see a green arrow in the direction of Risk Potential, showing a weak Relation (.24) with this safety element, and meaning that the more dominantly leaders behave, the more potential risks are expected.

Mediator's influence

In this analysis we note that Motivation to intervene has a negligible effect on the Sense of Safety (green arrow), a weak negative effect on Event History and a negligible effect on Risk Potential (both red arrows).

8.4.5 *Action related effects.*

In this section we present the results of the SEM path analysis related to the Action risk reduction phase.

Analysis results

The SEM path analysis results for cases in which Action acts as a mediator between the four leadership orientations and the three safety characteristics are shown Table 18 below.

Risk reduction phase: ACTION		**Event History**	**Sense of Safety**	**Risk Potential**
Explained variance		.201	.301	.023
Leadership orientation	**Effect**	**Standardised regression coefficient**		
Relation	**Direct**	.33	-	-
	Mediated	.05	-.04	-
Process	**Direct**	-.43	.35	-
	Mediated	-.14	.12	-.07
Production	**Direct**	.17	-	-
	Mediated	.03	-.03	-
Dominance	**Direct**	.37	-	.22
	Mediated	-	-	-

TABLE 18 Leadership effects (mediator: Action)

A graphical representation of the standardised regression coefficients as included in the above analysis table is shown in Figure 31 below.

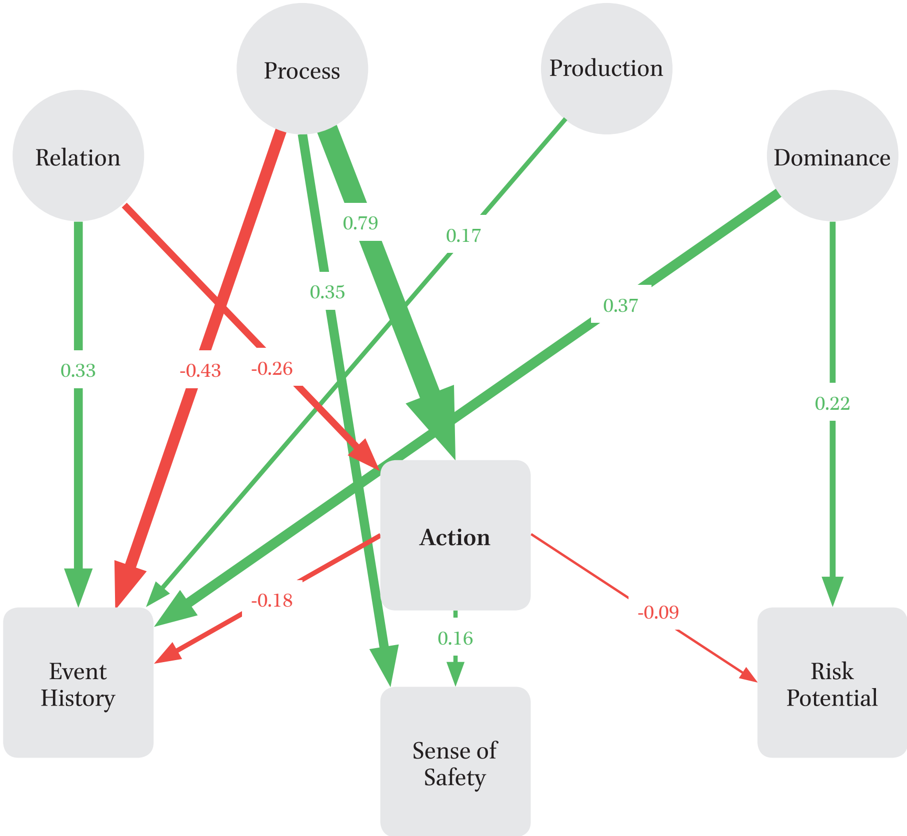


FIGURE 31 Significant effects (mediator: Action)

Explanation of effects per leadership orientation

Relation-oriented leaders

The green arrow leading to Event History shows that Relation-oriented leaders have a medium-strong positive effect (.33) on the occurrence of safety incidents. A red arrow in the direction of remedial Action, shows a weak negative effect (-.26) on this mediator.

Process-oriented leaders

We see a red arrow in the direction of Event History for Process-oriented leaders, which means that they have a medium-strong reducing effect (-.43) on the occurrence of safety incidents. We also observe two green arrows, indicating that Process-oriented leaders have a strong positive effect (.79) on remedial Action and a medium-strong positive effect (.35) on the Sense of Safety for the respondents of this survey.

Production-oriented leaders

Production-oriented leaders have a weakly positive effect (.17) on the occurrence of incidents (shown by the green arrow leading to Event History), and also a weak negative effect (-.19) on remedial Action. Leaders behaving in a Production-oriented manner thus prompt safety incidents and dampen the timely implementation of remedial Action.

Dominance-oriented leaders

The green arrow pointing at Event History shows that leaders in this group have medium-strong positive effects (.37) on the occurrence of safety incidents. We also see a green arrow in the direction of Risk Potential, showing a weak Relation (.22) with this safety element, and meaning that the more dominantly leaders behave, the more potential risks are expected.

Mediator's influence

In this analysis we note that the Action risk reduction phase has a weakly positive effect on the Sense of Safety (green arrow), a weakly negative effect on Event History, and a negligible effect on Risk Potential (both red arrows)

The next chapter presents the valorisation of our research. We present the answers to the research questions, and explain what these findings mean to us.

The idea that the future is unpredictable, is undermined every day by the ease with which the past is explained.

DANIEL KAHNEMAN

9 Retrospective views

9.1 The view of incident investigators

A group of 18 professional incident investigators reviewed 19 different investigation reports of major incidents distributed over six business sectors (tank storage, hospitals, the oil and gas industry, rail infrastructure and the process industry). No professional incident investigator meeting our selection requirements (competence and professional experience) could be identified for the general infrastructure sector. The 'Other' business sector was considered too non-specific for use in this review. Each investigator reviewed an investigation report[1] selected from their own occupational history. These analyses were conducted in the period between August 2017 and January 2019. The investigators were asked to scrutinise these reports regarding: a) the risk reduction phases that were compromised, and through which major incidents could occur, and b) the leadership orientations of the leaders who were instrumental in causing the major incident under review. The request was accompanied by detailed guidelines for conducting this review. These guidelines are presented in Appendix 15.2.

The investigators were asked to judge the extent to which the risk reduction phases contributed to the events with a score from 0–5 (0=no contribution, 5=high contribution). Their judgements resulted in the following scores per risk reduction phase: Recognition 204, Ability 185, Motivation 156, Courage 151, Action 178. These scores show that the investigators consider the Recognition (of risks) as the risk reduction phase contributing most to the causes of these 19 major incidents. This main contributor is followed by Ability (to intervene) and (remedial) Action. Motivation (to intervene and Courage (to intervene) were considered the least important contributing factors.

The investigators identified 64 leaders who contributed to the causes of these 19 events. The investigators were asked to judge the applicable leadership orientation of each contributing leader with a score of 0–5 (0=no contribution, 5=high contribution). Their judgements resulted in the following total scores per leadership orientation: Task 256, Relation 158 and Self 164. These scores show that the investigators considered

1 One investigator provided two reviews.

Task-oriented leaders as most instrumental in the causation of the major incidents under review.

We conclude that the reviews of 19 major incidents by 18 professional incident investigators suggest that recognition of risks is the least controlled risk reduction phase, and that Task-oriented leaders are most instrumental in causing major incidents.

9.2 The view of risk analysis experts

Risk reduction starts with the recognition of risks. In that respect, recognition is considered of paramount importance to a successful risk reduction process. In the previous section we reported that the professional incident investigators consulted consider Recognition the most compromised risk reduction phase. This suggests that there is often a lack of understanding regarding safety risks, or that they are ignored, which contributes seriously to the occurrence of major incidents. Based on this observation we considered it useful to obtain multiple independent opinions with respect to understanding, underestimating or ignoring safety risks in organisations. The business sector in which (the control of) major hazards is recognised as part of day-to-day operations was chosen as the most applicable sector on which to focus. We therefore invited five different risk analysis experts with extensive expertise in the field of risk analyses in 'major hazard' (BRZO) organisations for interview. These experts were selected on the basis of their individual experience in the field of risk analysis. Four of the five interviewees have used numerous safety risk analysis methods as part of their occupational practice for several years, and one interviewee has extensive experience reviewing risk analyses in major hazard organisations, from a governmental position.

The experts were individually interviewed in a semi-structured way according to a predetermined conversation guide. These interviews focused on the role of risk identification and assessment in the prevention of safety incidents. The interviews were guided using the following questions: Do you have knowledge of how organisations deal with risks? What can you tell us about this? Do people in the workplace know the safety risks? Are their supervisors aware of the risks in the workplace? Is this the same for management? What is your experience with corrective actions when risks are identified? Where are the problems? Do you have examples of incidents in the processes where you yourself were involved in the risk inventory/analysis? If so, was there a relationship/no relationship between the identified risks and the incidents? These questions served as guidance, and were posed if and when they were considered applicable in order to obtain as much information as possible from the different interviewees, without disturbing the natural flow of the interviews.

The following is a summary of the most salient topics in the interviews.

Barriers hampering the influence of risk identification/analysis

The interviewees did not paint a positive picture about the influence of risk analyses in major hazard organisations. According to these experts, risk analysis suffers from some inherent difficulties, such as the required combination of creativity and technological expertise in one person, the limited imagination of people combined with the invisibility of complex risk scenarios,[2] the unpredictability of human error,[3] the subjective nature of risk assessment, the potential operational restrictions caused by the identification of design flaws, and the complex communication process required to ensure that operational staff are informed about the identified risks and aware of how to deal with them in their practice.

The interviewees noted several barriers affecting the quality of risk analysis processes. We summarise these barriers as: team composition (number, expertise, mix, hierarchy), validity of documentation (e.g. P&ID), time constraints (insufficient time allocated to investigate unexpected findings), loss of data (due to malfunctioning ICT), incompatible interests (competition and distrust between departments/organisations),[4] loss of momentum (no periodical analyses, or monitoring the influence of preventive measures during operations), driven by compliance[5] (certification, license to operate), commercial influence (suppliers hiding information), limited scope (methods used don't cover all risks), application (differentiation between standard operations and start-up/shut-down, maintenance),[6] and language barriers.[7] An important barrier with operational implications for risk analyses is the lack of unambiguous international norms for process risks, which prevents the objective evaluation of safety risks, and the acceptance of risk analysis reports by the different parties involved.[8]

In summary, the experts we interviewed to obtain their views on the influence of the risk analysis practice in major hazard organisations, suggested that the identification and assessment of safety risks is a subjective and incomplete process. Common practice does not produce a reliable representation of all potential safety risks. Organisations pretend that they have tackled all risks, but experts wonder whether it is possible to identify and analyse all risks.[9] Many risk analyses are performed in an inadequate manner, but the reports comply with governmental regulations. Leaders live in an illusionary world, believing that their operations are safe.[10, 11] It should not therefore be surprising when major incidents occur as a result of unrecognised risks.[12]

2 Perrow (1999).
3 Groeneweg (1992), p. 22.
4 Beck (1986), p. 6.
5 Kluin (2014).
6 Reason (1997), pp. 85–104.
7 Lindhout and Ale (2009).
8 Fischhoff and Lichtenstein (1984), pp. 61–63.
9 Pasman (2015), pp. 168–171.
10 Motet and Bieder (2017).
11 Beck (1986), p. 28–32.
12 Taleb (2010).

Risk awareness of operating staff

The experts were pessimistic about risk awareness at work floor level. One expert suggested that people in operations do know the safety risks, but also that there is a trend of *Normalisation of deviation*, meaning that certain deviations from safe practices have become the normal way of working. The other four experts explained that, for various reasons, the operating staff's knowledge of risks is insufficient. A lack of information communicated from risk analysis teams to operating staff seems to be an important reason.

Risk awareness by leaders

The answers to the question of whether supervisors are aware of the safety risks are also a cause for concern. Reasons include a lack of information, poor communication, or that risk analysis is considered 'owned' by technical departments. The experts are clear that operational leaders lack knowledge about the major hazards.

9.3 The view of the Dutch Safety Board

Summary

When a safety incident is considered to have a potentially major impact, the Dutch Safety Board may decide to investigate its causes.[13] The scope of investigations is not limited to one particular sector or activity, but involves organisations of different types, in different domains. Where leadership is mentioned in a board's reports as a contributing factor, this often refers to leaders at different levels in the organisation's hierarchy, from chairpersons and CEOs to shift leaders at work floor level. Once the board's investigation reports have been published, the leaders of the organisations concerned are under the spotlights of the (inter-)national press, other media, peers, principals, clients, authorities, and so on.[14, 15, 16, 17, 18, 19] Public communication by these sources regarding a lack of leadership as one of the causes of a safety incident puts these leaders in very uncomfortable positions, and may affect the reputations of the organisations they lead.

Twelve investigation reports by the Dutch Safety Board (*Onderzoeksraad voor Veiligheid*) into safety incidents in the Netherlands were analysed as part of this research. This stage of the research was introduced after we considered the results of the reviews with the incident investigators, who suggested that insufficient recognition of risks is in an important reason for major incidents. This suggestion was the reason for investigating the role played by the recognition of safety risks. The board has investigated many (potential) major incidents since its founding, in many different business sectors.

13 Rijkswet Onderzoeksraad voor veiligheid (2004).
14 Onderzoeksraad voor Veiligheid (2007).
15 Onderzoeksraad voor Veiligheid (2008a).
16 Onderzoeksraad voor Veiligheid (2008b).
17 Onderzoeksraad voor Veiligheid (2012).
18 Onderzoeksraad voor Veiligheid (2013c).
19 Onderzoeksraad voor Veiligheid (2015).

In this section we present a selection of major incidents which have occurred in the business sectors considered by this research, and which were investigated by the board. The investigation reports considered were selected according to the following selection criteria: 1) the variety of the specific domains; and 2) their relatively high community impact. Our analysis included the tank storage, hospital, rail infrastructure and general infrastructure sectors, the process industry, and the oil and gas industry. The 'Other' category was not considered as it does not represent a specific area of investigation. We focused on the board's reporting of the role of risk awareness and risk assessment as contributors to these incidents in our review.

Tank storage

Report #1: This investigation was conducted due to an environmental spill caused by the rupture of a storage tank bottom. Concerning the cause of the spill, the board concluded that: "… it was known that the technical state of the tank exceeded the acceptance criteria of EEMUA 159 and one was aware of the risks involved. Nevertheless, based on the argument that the Licence to Operate did not require the tank quality to be tested according to these EEMUA 159 criteria, the organisation did not act upon that awareness", and "… due to the lack of historical information about the construction of the tank, the organisation was not able to use the knowledge of the weak tank support and the safety risks involved."

Report #2: This investigation was conducted due to an uncontrolled situation at the tank storage farm, creating increased safety risks for employees. Concerning the cause of this uncontrolled situation, the board concluded that: "…the company had no complete insight into its primary processes, installations and the safety risks involved", "… as there was no way to conduct an effective hazard identification process, there was no complete picture of the major risks", "… the risk identification of process safety risks was performed in an insufficient way", "… the risk identification of hazardous substances is insufficient and inadequate", and "… many of potential incident risks have not been assessed in the HAZOP-study…".

Hospitals

Report #3: This investigation was conducted due to the deaths of several patients after or while undergoing weight-loss surgery. Concerning the cause of these deaths, the board concluded that driven by the aspiration of innovation, "none of the parties involved viewed the introduction of bariatric surgery as an innovation of care provided that introduced particular risks for patients…", "none of the parties involved with the hospital displayed awareness of the risks of bariatric surgery, its complex forms in particular", and "…insight into the interrelated risks was largely absent…"

Report #4: This report by the board was prompted by the identification of high mortality rates after heart surgery. Concerning the cause of this mortality, the board concluded that: … "the managerial activities related to risk analysis and learning from incidents in the hospital were not aimed at (having) an inventory of risks in the primary business process. Rather, the Board of Directors focused on external risks and threats to the primary business process, such as competition from other hospitals.

Process industry

Report #5: This report concerns the investigation of an event comprising two severe explosions, followed by a large fire. Two employees were seriously injured in these incidents, and an immense amount of damage was caused to assets. Debris was retrieved at a distance of around 800 metres from the place where the explosion took place. The blast was heard 20 kilometres from the plant. A very large local fire generated considerable amounts of smoke. Concerning the cause of this incident, the board concluded that: "… the company failed to identify and control the risks associated with the plant modifications and with the execution of chemical processes …", that "… earlier modifications did not always lead to a new risk analysis. The subject chemical reaction failed to be identified as a result…", that "… work instructions were inadequate, which was not identified, creating risks that Shell Moerdijk failed to control…", that "… the company failed to recognise that the subject process, involving a reactor vessel containing ethylbenzene and this catalyst, is always dangerous to work with in itself…", and that "… various signals concerning the risks that arose failed to be recognised and dealt with as such."

Report #6: This investigation was prompted by four serious safety incidents at a multi-company chemical site. One of these incidents caused fatal injury. The majority of the technical assets on this site were old (> 40 years in service). Concerning the factors of causation in these incidents, the board reported the following general findings: "… the inspection and maintenance of installations is inadequate…", "…work instructions are inadequately used…", "… there is insufficient learning from incidents", "… flawed risk identification…", "… flawed risk assessment", and "… insufficient awareness of process parameters…" Based on these findings the board concluded that: "These factors involve weaknesses in the control of process safety and indicate a lack of systematic research into possible improvements in the control of process safety in the chemical installations as a whole."

Oil and Gas industry

Report #7: This investigation was due to the explosion of a natural gas condensate tank, resulting in two fatalities, one seriously injured person and severe material damage. Concerning the cause of this explosion, the board concluded that: "…The officials for the client and the contractors involved insufficiently identified the process safety risks. The process safety risks that were identified were underestimated and the safety measures planned were insufficiently executed."

Report #8: This investigation was due to earthquakes caused by the exploration of natural gas, resulting in severe damage to many buildings in the area. Concerning the cause of these earthquakes, the board concluded that: "…the parties involved did not regard earthquakes as a safety concern for the citizens of Groningen", "… the parties concerned deemed the safety risk to the population negligible, and thus disregarded the uncertainties surrounding this risk assessment."

Rail infrastructure

Report #9: This investigation was due to a rail grinding train on a transfer journey colliding with a building (shop), resulting in severe material damage. Concerning the cause of this collision, the board concluded that: …" the companies involved did not adequately map the risks involved in this type of journey…", "… the companies were not aware of some of the risks of transfer journeys and limited themselves to other risks as described in legislation…", and "…the companies involved did not sufficiently recognise the specific safety risks of transfer journeys…"

Report #10: This investigation was due to a collision between a train and a mobile lifting platform, resulting in the death of the train driver, three slightly injured people and severe material damage. Concerning the cause of this collision, the board concluded that "…risk assessments do not include the risk of trains colliding with heavy vehicles…", "… the risk of crossing the rails was assessed too optimistically by the driver of the vehicle…", and "… road managers are not adequately safety aware of this type of risks.…"

General infrastructure

Report #11: This report was based on an incident in which two barge-based cranes toppled while lifting a bridge deck (187 tons dead weight), causing serious equipment damage (the bridge deck and total loss of both cranes, among other assets), and the destruction of houses and shops. Concerning the cause of this incident, the board concluded that: "None of the parties involved realised that lifting the bridge section entailed risks to the environment and for citizens." "None of the parties realised that for this reason there were potentially serious consequences for local residents." "All parties involved had a blind spot for the safety of the surrounding area during the preparation and implementation of the bridge renovation."

Report #12: This investigation was conducted due to multiple incidents (suffocation) related to carbon monoxide, causing between 5 and 10 fatalities, and some hundreds injured people per annum, plus an unidentified number (estimated at 3 to 5 times these numbers) of fatalities not formally related to carbon monoxide. Concerning the cause of these incidents the board concludes that: "… the hazard of carbon monoxide is an underestimated problem." "The board identifies gaps in the system that must provide guarantees for the supply of safe products (combustion installations and carbon monoxide detectors) and the services provided by expert installers. The Netherlands is lagging behind compared to neighbouring countries."

9.4 Summary

Based on the conclusions of the Dutch Safety Board regarding the causes of major incidents as presented above, we suggest that all reviewed incidents could have been prevented if the safety risks had been identified and risk management mechanisms had been in place and functional. The reports by the Dutch Safety Board offer proof that seemingly safe operations still may contain weaknesses where the management of safety risks is concerned. Society does not take these potential unsafe situations for granted and therefore many organisations risk the loss of public reputation. This is considered a serious business risk, and so organisations, voluntarily or as required by law, put much effort into the development of better, more effective risk management philosophies, methods and practices.

Whether there will actually be a major incident and its potential maximum severity has much to do with the specific context which allows the devastating energy to be available, how this availability develops in a specific form of loss of control, and what coincidental influences stimulate the trigger for an event to occur. Dekker refers to this process as “Drifting into failure.”[20] Even when that failure has materialised and the damaging energy has managed to become uncontrolled, the outcome of the event remains uncertain. Groeneweg refers to this situation as the “irreducible unpredictability and disorder of the outcomes.”[21] Uncertainty is thus an inescapable factor that must be taken into account where it concerns the predictability of major incidents and the ability to identify, assess and manage the risks by taking the right preventive decisions.[22, 23, 24, 25, 26, 27] In that respect Pasman argues: “Incident scenarios can be very diverse and therefore difficult to predict, at least with respect to details about how an event will initiate, develop, its likelihood and what influences it will have.”[28]

The incident reviews referred to in this chapter demonstrate the confidence of members of organisations that their primary processes were safe at the time they decided to operate them, but this confidence is based on individual perceptions about the absence of potentially dangerous threats, and/or the likelihood that these threats will develop into a major incident. In that illusory certainty, all people involved, whether leaders vis-à-vis their followers, doctors vis-à-vis their patients, train drivers vis-à-vis their passengers, and so on, are convinced about the acceptability of the level of safety in their area of

20 Dekker (2011)
21 Groeneweg (1992)
22 Fischhoff and Lichtenstein (1984)
23 Dekker (2011)
24 Perrow (1999)
25 Groeneweg (1992)
26 Reason (1997)
27 Van Asselt (2000)
28 Pasman (2015), p. 28.

responsibility, or in their positions as potential victims of safety incidents.[29] Often, they are right, but sometimes they are proved very wrong.

The next and final chapter presents the final conclusions of this research, including recommendations for fostering Process-oriented leadership. This chapter also explains the applicable limitations of this research, and makes proposals for further research.

29 Motet and Bieder (2017)

The Fixed mindset makes you concerned with how you'll be judged; the Growth mindset makes you concerned with improving.

CAROL DWECK

10 Valorisation

This research aimed to answer the principal research query of whether leaders can help to prevent safety incidents. This answer is considered a valuable guide with respect to enabling leaders to lead their teams in the delivery of the required product or service, while ensuring the safety of the operations. In high-risk processes where the prevention of safety incidents is considered of primary importance, even if-and-when it interrupts or halts the production process, 'safety leadership' is more important than all other roles of leaders.

We discussed the effects of leaders of different orientations on operational safety, and ultimately identified the orientation that will probably lead to optimal incident prevention. Our research was guided by the presumption that safety is increased when risks are reduced, and that leaders affect this risk reduction process. In order to achieve our aim, we initially introduced a Risk Reduction Cycle, explaining five specific phases to be accomplished in order to reduce safety risks. We then designed a Safety Leadership Model, explaining the relationships between (the levels of) Safety, Risk Reduction Capacity and Safety Leadership. In order to identify these relationships, we examined 33 different organisations in six different specific business sectors through five different lenses: prospectively through an online survey among 4561 respondents, followed by reflections on the survey outcomes by senior leaders; retrospectively by analysing incident reports; verbally by interviewing risk analysis experts; and visually by reviewing incident reports by the Dutch Safety Board. These different approaches generated some interesting insights regarding how different orientations of leaders affect the safety of their operations.

In this chapter we discuss the most salient results of this research, and evaluate our findings with respect to their value in an operational setting. First, we present our findings about the three individual nodes of the Safety Leadership Model: Safety, Risk Reduction Capacity and Safety Leadership. We will then focus on the relationships between these nodes through the resolution of three research questions. Following that we will discuss the meaning of the findings of this research, and, as proof of the value of this study, we will explain the applicability of the Safety Leadership Survey as a means to establish and develop Safety Leadership.

10.1 Findings

10.1.1 *Safety*

The results concerning the 'Safety' node in the Safety Leadership Model explain that our survey respondents experience a relatively low number of safety incidents in their organisations, and that, individually, their sense of the safety in their workplace is relatively positive. In general, our respondents indicated that they are comfortable about the future, as they expect a relatively low level of potential risk. When comparing the six different specific business sectors, however, we found that the hospital sector and the oil and gas industry are exceptions to this. These two sectors stand out as particular risky sectors in which a comparatively large number of safety incidents are recorded, and where employees clearly don't feel as safe as in other sectors.[1]

10.1.2 *Risk Reduction*

Regarding the 'Risk Reduction Capacity' node, our respondents clearly reported that operational level safety risks are well recognised. This means that our respondents pretend that risk awareness is well in place. Another salient finding is that these respondents reported that, after a risk was recognised and communicated, the required remedial Action is not taken, or not taken in a timely manner. Interestingly, we also obtained contradictory information in connection to these findings. Professional incident investigators reported that not recognising risks is considered the most common contributing cause of major incidents. Experienced risk analysts explained that, due to the substandard quality of risk analyses in hazardous processes, major incidents are often caused by unforeseen risks, not identified in hazard analysis processes, and therefore not recognised by operational staff, nor by their leaders. Many incident investigation reports, as issued by the Dutch Safety Board, describe 'lack of risk awareness' as an important contributor to major incidents. The perception of our respondents that people at an operational level clearly recognise the safety risks around them, is thus not supported by experts.

What do these different views mean?

The effective detection of risks requires process knowledge, motivation to actively find and report risks, vocational experience, process expectations, and some luck (in finding unanticipated risks). Our research findings suggest that these qualities are not always present to a sufficient degree to warrant the effective recognition of safety risks.

We also learned that many safety risks are discovered in retrospect, after incidents have taken place. Incident investigators use multiple resources; they examine the location by looking sharply around, listen to people, read documents and find all that can reasonably be found, including information not accessible by operational staff. Investi-

1 Here it should be noted that the Event History scores of respondents working in hospitals are probably focused on patient safety incidents. The text offered for the Sense of Safety ("I feel safe in my organisation") means that the respondents' focus is on themselves here.

gators, in their independent role, have the power to demand access to all relevant information, to look anywhere necessary, to interview people (regardless of their hierarchical position), to read all documents they consider relevant to their investigation, and to combine and interpret this different data. Incident investigators thus have the opportunity to see and hear what was invisible (or simply not observed), unheard, and sometimes also unimaginable (or not imagined) before the investigated incident, at least to the people operationally involved. In this way incident investigators discover information previously unknown, and therefore often draw surprising conclusions regarding an organisation's management and operational staff. The incongruence between retrospective observations by expert investigators and the limited risk awareness of people in operations, should not therefore be considered contradictory, but as a logical result of the different opportunities inherent in prospective and retrospective views. The different views identified show a gap in risk awareness, which, we believe represents the true picture of the real world.

10.1.3 *Safety Leadership*

An interesting finding was noted with respect to the Safety Leadership node. Initially, based on the leadership literature, we specified the characteristics of leadership behaviour using three behavioural orientations: Task, Relation- and Self orientation., We designed our survey questionnaire on the basis of that theoretical framework, and it was used in an online prospective survey. In this framework the Task behavioural orientation referred simply to Production-oriented behaviours, but after we subjected the acquired survey responses to EFA and CFA analyses, we discovered that the behavioural orientation actually included two distinctly different sub-orientations. These factor analyses revealed that one part of the related indicators emerged as indicators for a *quantitative* approach to the primary production process of an organisation, while the other related indicators were predominantly indicative of a *qualitative* approach to the primary production process. Following this discovery, we decided to separate the initial Task behavioural orientation into two different orientations; a primarily quantitative or Production-related orientation, which we named 'Production' and a qualitative or Process-related orientation, which we named 'Process'.

Based on these findings, we re-arranged the three original behavioural orientations into four different leadership orientations: Production, Process, Relation and Dominance.[2] We also shortened the term "behavioural orientation" to "orientation", which implicitly implies someone's behaviour. This rearrangement of leadership orientations resulted in a final taxonomy for classifying leadership indicators (ref. 7.4).

2 We renamed the "Self orientation" as a Safety Leadership orientation as "Dominance orientation", which was considered a more appropriate term.

10.2 Resolution of research questions

We proposed the following research questions related to the relationships between Safety Leadership, Risk Reduction Capacity and Safety in order to resolve the principal research query (*"Can leaders of organisations help to prevent safety incidents?"*):

1. Does risk reduction relate to safety in organisations?
2. Do leaders' behavioural orientations (read: orientations) relate to risk reduction?
3. Do leaders' behavioural orientations (read: orientations) therefore relate to safety in organisations?

A Structural Equation Modelling path analysis (ref. 8.4) showed that leaders demonstrate their influence over safety according to two different pathways: a) *indirectly* (or mediated) by the risk reduction process, and b) *directly* due to the effect of Safety Leadership behaviours on the Safety node. These two pathways are visualised in Figure 32 below.

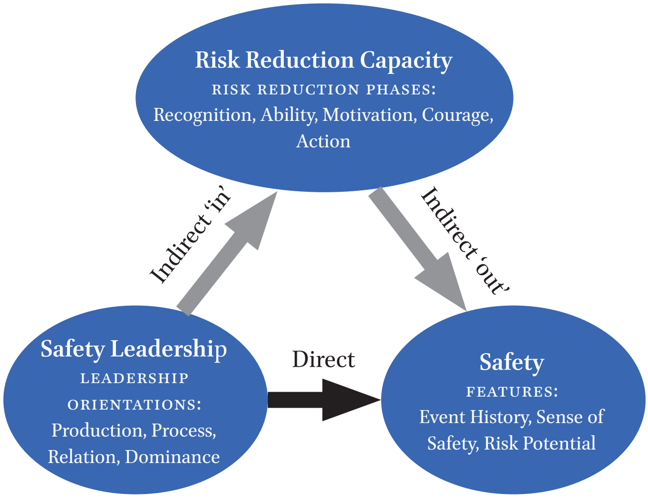


FIGURE 32 Direct and indirect influences on Safety

We will distinguish these two different pathways when resolving the three research questions. We thus present the nodes of the Safety Leadership Model as three different relational levels: Safety Leadership, Risk Reduction Capacity and Safety. These levels are visualised in below Figure 33.

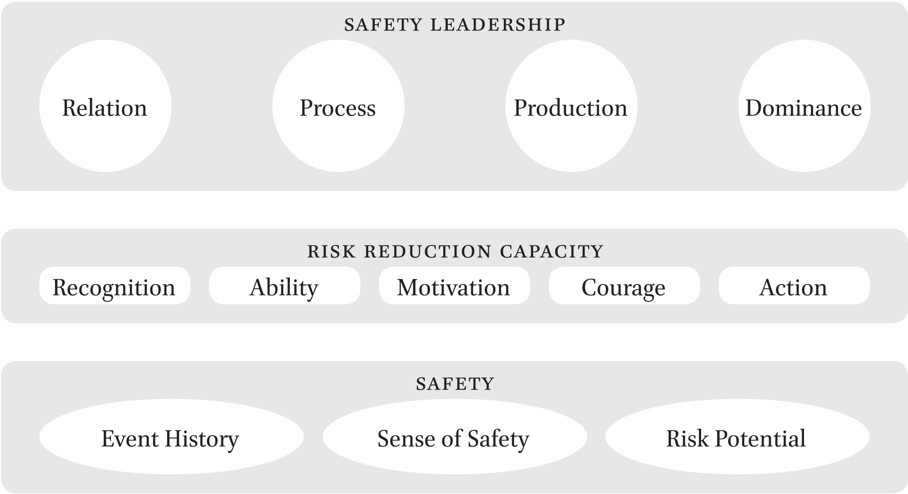


FIGURE 33 Three relational levels of the Safety Leadership Model

Next, we will resolve the research questions.

10.2.1 *Does risk reduction relate to safety in organisations?*

This question concerns the 'downstream' sector of the mediated pathway from Risk Reduction Capacity to Safety, in Figure 32, indicated as Indirect 'Out'.

SEM path analysis showed that the answer to this research question is partly positive; the five different risk reduction phases do indeed affect safety, but in individually different ways. These individual influences are shown in Figure 34 below.

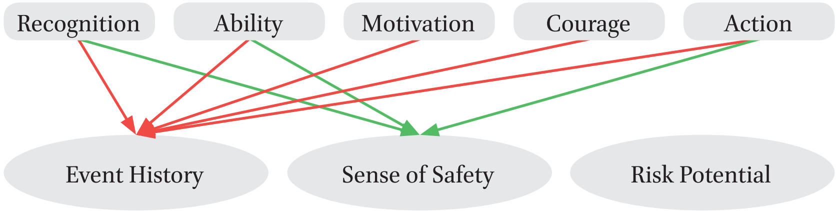


FIGURE 34 Influences of the risk reduction phases on safety

Green arrows represent the positive effects of risk reduction on safety, and red arrows represent the negative effects of risk reduction on safety. We specify these different effects below.

The risk reduction phases showing a negative effect on Event History (preventing safety incidents) and a positive effect on the Sense of Safety are *Recognition, Ability* and

Action. If we apply the features related to these risk reduction phases to this outcome, we see that the combination of an optimal recognition of risks, by competent staff, who know what to look for, who are offered the opportunity to intervene and who are working in an environment where safety risks are remedied in a timely manner, is an effective recipe for reducing safety incidents and generating a positive Sense of Safety for followers.

The *Motivation* and *Courage* risk reduction phases both also showed negative effects on Event History (preventing safety incidents), but these risk reduction phases only had negligible effects on the Sense of Safety of our respondents. These findings suggest that these risk reduction phases do indeed have a reducing effect on the occurrence of safety incidents, but that efforts made by organisations to improve people's motivation, and programmes to stimulate their courage to intervene, will probably not improve their employees' appreciation of safety.

Finally, the SEM path analysis revealed that none of the risk reduction phases have any noteworthy mediating effect on potential future risks, which, due to the very nature of the risk reduction process, is an understandable finding.

A table showing the standardised regression coefficients of these relationships is presented in Appendix 15.10.

10.2.2 *Do the behavioural orientations of leaders relate to risk reduction?*

This question concerns the 'upstream' sector of the mediated path from Safety Leadership to Safety, shown in the above Figure 32 as Indirect 'In'. The SEM path analysis showed that the answer to this research question is also partly positive, meaning that leaders with different orientations have different effects on the five different risk reduction phases. These individual influences are shown in Figure 35 below.

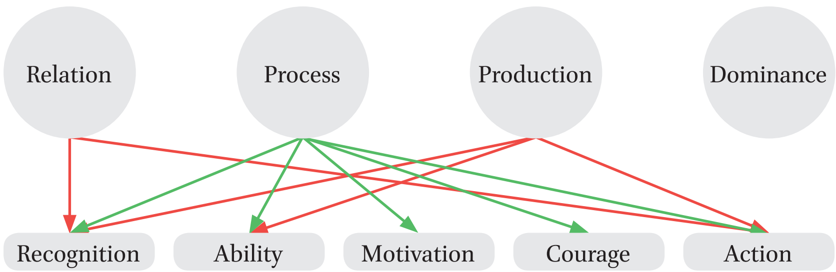


FIGURE 35 Influences of Safety Leadership orientations on risk reduction

Green arrows represent the positive effects of Safety Leadership on risk reduction, red arrows represent the negative effects of Safety Leadership on risk reduction. We explain these different effects according to the leaders' different orientations below.

Relation

Leaders exhibiting a Relation orientation are good listeners, they are compassionate and facilitating, they empower their fellow workers and they support a good working climate. Relation-oriented leaders negate the value of the Recognition of risks, however, as well as remedial Action. Our findings also suggest that Relation-minded leaders have no significant influence over Ability, Motivation or Courage to intervene.

Process

Leaders who have a Process orientation distinguish themselves by their ability to motivate their followers to intervene in safety risks, who can forgive people when they do this when there was no real need, who ensure that necessary improvements are made, and who credibly convey the message that operational safety is their top priority.

According to our survey outcomes, Process-oriented leaders support all risk reduction phases that is, Recognition of risks, Ability, Motivation, Courage to intervene and timely execution of remedial Action. These findings suggest that leaders who show a Process orientation have a positive influence on the entire risk reduction process.

Production

Production-oriented leaders are focused primarily on production targets. They are recognised by their decisive nature and intuitive actions. These leaders have the courage and do whatever they consider necessary, even when procedures prescribe differently. According to our survey outcomes, leaders with a Production orientation have a negative influence on the Recognition of risks, Ability to intervene and remedial Action. These leaders also have no significant influence on Motivation or Courage to intervene.

Dominance

Dominant leaders behave individualistically and value hierarchical status. They abuse the goodwill of other people and come across as hostile. According to our survey outcomes, dominant leaders do not have any significant influence on any risk reduction phase.

According to the above explanation of our survey outcomes, we argue that Process-oriented leaders are most effective where the relationship between leader orientations and risk reduction is concerned.

A table showing the standardised regression coefficients of these influences is presented in Appendix 15.9.

10.2.3 ***Do leaders' orientations therefore relate to safety in organisations?***

We argued that the influence of leaders regarding safety follows two different paths: one path from Safety Leadership to the Safety node, *mediated* by the Risk Reduction Capacity node, and a *direct* path from the Safety Leadership node straight to the Safety node. In this section we present the influences of Safety Leadership on Safety for both pathways.

First, we show the results of the mediated influences, and then the direct influences.

Indirect (mediated) influences of Safety Leadership on Safety

The mediated influences of leader orientations on safety involve the indirect pathways from Safety Leadership, via Risk Reduction Capacity, to Safety. In Figure 32 this is shown in the pathways running from Safety Leadership, via 'Indirect 'In'', Risk Reduction Capacity and 'Indirect 'Out'' to Safety. In fact, the full mediated pathway represents the influence of Safety Leadership on the five risk reduction phases (shown above in Figure 35) followed by the influence of the five risk reduction phases on Safety (shown above in Figure 34).

The SEM path analysis of mediated relationships suggests that, in comparison with the above separate Safety Leadership-risk reduction and risk reduction-Safety relations, the mediated influences of Safety Leadership on Safety are reduced. After investigating this finding, we found that this phenomenon originates in the relatively low regression coefficients between the risk reduction phases and the safety characteristics, as identified by the SEM analysis. These low regression values have a detrimental influence on the mediated influences of leaders regarding Safety. The result of these influences is shown in Figure 36. below.

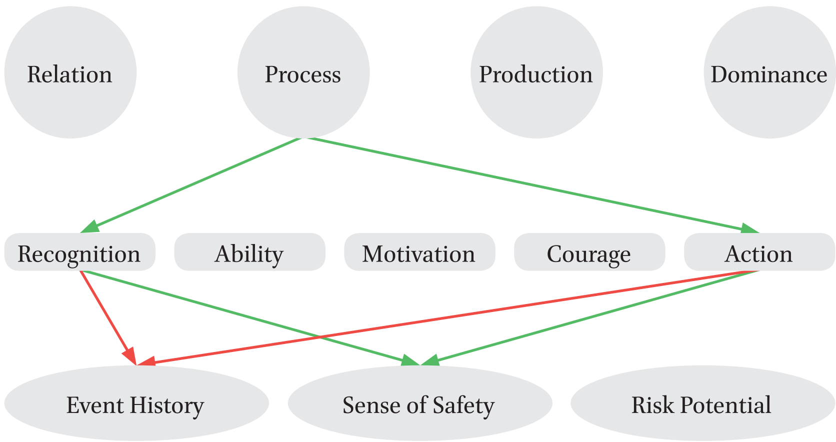


FIGURE 36 Mediated influences of leaders' orientations on safety

Green arrows represent the positive mediated influences of leader orientations on safety, and the red arrows represent the negative mediated influences of leader orientations on safety. We explain these different influences below.

The outcomes of the SEM path analysis for the mediated relationship between Safety Leadership and Safety suggest that only *Process-oriented* leaders affect safety, and specifically when mediated by the Recognition and Action risk reduction phases.

Process-oriented leaders affect Event History through these pathways, as well as the

Sense of Safety. None of the other Safety Leadership orientations (Relation, Production and Dominance) reached the minimum required standardised regression coefficients, and are therefore considered of negligible influence on safety via indirect pathways.

Direct influences of Safety Leadership on Safety

The direct influence of leader orientations on safety relate to the other, direct path from Safety Leadership to Safety. This path is indicated in Figure 32 as the 'direct' pathway. The SEM path analysis revealed that the answer to this research question is also partly positive, meaning that the five different orientations of leaders influence safety, but each in an individually different way. These influences are shown in Figure 37 below.

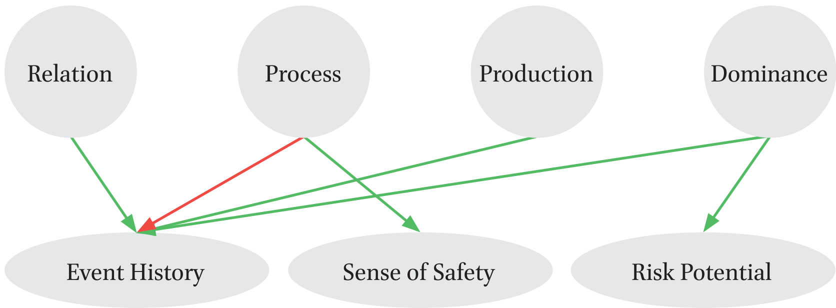


FIGURE 37 Direct influences of leaders' orientations on safety

Green arrows represent the positive direct influences of leader orientations on safety, and the red arrows represent the negative direct influences of leader orientations on safety. We explain these different influences below.

Process-oriented leaders showed a negative direct influence on Event History and a positive direct influence on Sense of Safety. This suggests that Process-oriented leaders have a preventative influence on safety incidents and stimulate a positive Sense of Safety in their followers.

The other orientations (*Relation, Production and Dominance*) show positive direct influences on Event History, suggesting that these minded leaders *increase* the potential for safety incidents to occur. These leaders do not show any significant direct influence on Sense of Safety. This suggests that they have negligible influence regarding their followers' Sense of Safety.

Only leaders with a *Dominance* orientation had a positive direct influence on Risk Potential, showing that people working for these leaders felt that there was the potential for future safety incidents in their organisations. Leaders with *Relation-, Process- and Production orientation*s do not show any significant direct influence on the potential for future incidents.

A table showing the identified standardised regression coefficients for direct and mediated influences of Safety Leadership on Safety is presented in Appendix 15.11.

10.2.4 *Summarized resolution of research questions*

The findings presented in the previous sections have resolved the three research questions as follows:

1. *Does risk reduction relate to safety in organisations?*

Risk reduction relates to safety in organisations in a limited way; only Recognition, Ability and Action show notable influences on Event History (preventing safety incidents) and on the Sense of Safety (inducing a positive Sense of Safety). Motivation and Courage only have a reducing influence on the occurrence of safety incidents. No influences on future Risk Potentials were identified.

2. *Do the behavioural orientations of leaders relate to risk reduction?*

Process-oriented leaders have positive influences on all risk reduction phases. Leaders with a Relation orientation relate in a negative way to Recognition and Action. Production-oriented leaders have negative influences on Recognition, Ability and Action. Dominant leaders do not have a notable influence on any risk reduction phase.

3. *Do the behavioural orientations of leaders therefore relate to safety in organisations?*

Leaders' orientations do indeed relate to safety in organisations.

In an *indirect* way, only Process-oriented leaders affect Safety; that is, when mediated by Recognition or Action, they have a negative influence on Event History (preventing safety incidents) and a positive influence on the Sense of Safety of their followers.

In a *direct* way, Process-oriented leaders have a negative influence on Event History (preventing safety incidents) and a positive influence on the Sense of Safety of their followers. Leaders with Relation, Production, or Dominance orientations have direct positive influences on Event History (inducing the potential for safety incidents), and do not have notable influences on their followers' Sense of Safety. Only leaders with a *Dominance* orientation have a (positive) direct influence on the safety characteristic Risk Potential, showing that people working for these leaders felt that there was indeed the potential for future safety incidents in their organisations.

10.3 What do these findings mean?

In the previous sections we presented our findings, obtained using research techniques that conform to contemporary scientific practice. These techniques revealed the perceptions of our respondents. In the following sections we will add meaning to our observations. This requires interpreting the previously presented findings in relation to the operational reality in the surveyed organisations, meaning that our scientific findings are applied to operational practice. We will use our own professional experience and risk management expertise in this process.

Perceptions steer behaviour

With reference to the Thomas[3] theorem, we presume that people's behaviours, among other things, are steered by their perceptions of reality. This applies to everyday life, and, supported by the work of Slovic et al.,[4] we argue that this similarly applies where employee perceptions of safety are concerned.

When people perceive themselves as having good knowledge of safety risks and a good sense about safety, they feel confident in that respect, and will show behaviours according to that state of mind. However, if people perceive that Action is not taken to intervene, and that risk-reducing interventions are not taken in a timely manner, they may conclude that safety is not taken seriously in their department. Regardless of whether the latter is true or false, they will then adapt their behaviours to this perception, and may sometimes they express dissatisfaction, refuse to cooperate, ignore safety measures, or, if they are able to, even decide to leave the organisations. In order to prevent this kind of working atmosphere it is important to be aware of the perceptions of employees, so that interventions can take place before a risky situation escalates. This awareness is what these survey results are about.

The outcomes of this research reflect the perceptions of the survey respondents. The acquired data shows how these employees see their leaders, and is indicative of the extent to which employees will cope with their leaders' behaviours, and vice versa. Such an indication may guide us regarding how to predict the influence of certain leaders on the safety of the primary processes they are supposed to lead, and may consequently play a role in the development of safety improvement strategies.

In the next sections we explain the meaning of the research findings concerning Risk Reduction Capacity, and concerning the influence of Safety Leadership on safety.

10.3.1 *Roles of the five risk reduction phases*

In Section 8.2.2 the survey data show the general findings about the five risk reduction phases. In addition to general findings, these data show some interesting differences between the business sectors. We elucidate these differences below.

10.3.1.1 Salient findings in risk reduction

Recognition

Taking into account the different outcomes of the acquired survey data on the one hand, and the testimonies of the incident investigators and the risk analysis experts and incident investigation reports by the Dutch Safety Board on the other hand, we found that many survey respondents were too positively biased. We therefore conclude that people working in operational spheres feel safer than they actually are. Based on this conclusion

3 Scott (2015).

4 Slovic, Finucane, Peters and MacGregor (2004).

we suggest leaders pay serious attention to the level of risk Recognition in their operations.

The discovery of this difference in risk perception offers leaders the opportunity to act by investigating the reasons behind the limited risk awareness of their followers, and to take appropriate action to improve this situation in their own organisations.

Remedial Action

We observed the lowest average scores of all for the Action risk reduction phase. In order to clarify this, we discussed this outcome with employees at different organisational levels: operational employees, safety professionals, supervisors and managerial leaders. The closer our participants were related to operations (or safety), the more agreement with these low scores we encountered.

None of the board members or managers returned a low score for Action. In several conversations with the researcher, they confirmed that they were unaware that any required Action identified was not executed in a timely manner. In contrast, people at supervisory level told us they were very aware of the perception by operational staff that Action was not taken in a timely manner. These supervisors associated this with insufficient feedback about the completion of remedial Action to the people (often operational or safety staff) who reported that Action had to be taken. According to these supervisors, adequate and timely remedial Action was usually taken, but, as some supervisors noted: "this was not always communicated to the work floor." This explanation did not match the statements by the operational and safety staff, however. The latter explained that they had scored this risk reduction phase relatively low, as in their experience that represented the real situation. We conclude that the risk reduction phase remedial Action typically involves differences in 'work as imagined and work as done.' We thus suggest that the risk reduction phase Action also requires particular attention. The data collected also offers leaders the opportunity to discover the reasons behind this situation and to take appropriate action to solve it.

Motivation

The second-highest average score was given for Motivation to intervene, suggesting a high level of trust in people's willingness to intervene, when risks were observed. This is a very important finding as it confirms that employees, when asked, claim they consider safety an important element of their work. This knowledge of positive orientation is considered an important lever for leaders when designing safety improvement strategies.

Ability and Courage

The scores for these two risk reduction phases are in the mid-range. Specifically, the scores for Courage to intervene do not seem to reflect an exceptional influence on risk reduction. We consider this surprising and important information, as many leaders in organisations take a lack of Courage by their followers as a strong reason for not intervening in production processes. We therefore conclude that reluctance to intervene may be caused by a lack of Ability to intervene, and not necessarily by a lack of Courage. These observations are important indicators for leaders who are responsible for the development of safety improvement strategies.

10.3.1.2 Differentiation by business sector

Improving safety means setting priorities. Here we show how the different business sectors are setting their priorities concerning risk reduction phases. We ranked the five risk reduction phases of the six specific business sectors in order to identify sector preferences.[5] We found both similarities and differences. We present the results of this ranking process in Table 19 below. The numbers in this table represent the different ranks as applicable to the different business sectors: 1 refers to the highest score, and 5 refers to the lowest score.

	Recognition	Ability	Motivation	Courage	Action
Tank storage	2	4	1	3	5
Hospitals	2	4	1	3	5
Process	1	3	2	3	5
Oil & Gas	1	5	2	4	3
Infrastructure general	1	2	4	5	3
Rail infrastructure	2	3	1	4	5

Legend:	Prevalent	Secondary	Mediocre	Marginal	Lowermost

TABLE 19 Ranking risk reduction phases per business sector

We explain the similarities and differences of the different rankings below.

Similarities

Although their primary processes are of entirely different natures, the business sectors tank storage, hospitals, process industry and rail infrastructure show relatively similar rankings. The only differences in ranking identified are the mutual reversals of the middle/marginal ranking of Ability versus Courage and the prevalent/secondary ranking of Recognition and Motivation. All sectors mentioned here show high rankings for Recognition and low rankings for Action. These rankings confirm the results described in the previous Section 10.3.1.1.

5 The data analysis generated by the non-specific ‘Other’ sector is considered irrelevant here.

Differences

Two business sectors show deviant rankings: oil and gas, and general infrastructure.

The rankings of Action and Ability stand out for the oil and gas industry. The relatively high ranking for Action confirms our suggestion in Section 6.4.1.2.2, that people who are potential victims of safety incidents are themselves optimally motivated to take remedial Action regarding identified safety risks. We are not sure about the origin of the deviances in the general infrastructure sector, as we have not been able to collect sufficient consistent information concerning this phenomenon. We estimate that this ranking pattern is caused by the variety of different primary processes in the surveyed organisations.

Risk reduction related meanings

Ranking the risk reduction phases of each business sector confirmed that organisations are not only optimistic about their skill to recognise risks in absolute terms (as described in Section 10.3.1.1), but also show their confidence in this skill in relative terms by ranking Recognition as the most common risk reduction phase. The low relative ranking of the remedial Action risk reduction phase also confirms the suggestion made in Section 10.3.1.1, that remedial Action regarding identified safety risks has low priority in these business sectors.

10.3.2 *Influences of Safety Leadership on Safety*

Different organisations employ different leaders with different orientations, who are differently focused. Not all leaders have the abilities needed to improve safety. Below we set forth the average different influences of the four different leadership orientations (Relation, Production, Dominance and Process[6]) on safety, as identified by the SEM analysis.

In this overview we will describe the direct (non-mediated) influences, followed by the indirect (mediated by the five risk reduction phases) influences of Safety Leadership on Safety.

Different leaders affect safety differently

Process-oriented leaders appear specifically focused on the quality aspects of the primary (production) process.[7] We discovered that Process-oriented leaders contribute strongly to the prevention of safety incidents through direct influences (described in Section 7.2.3.2), and having a strong positive influence on the Sense of Safety of their followers. In addition to these direct influences, Process-oriented leaders, as the only type of leader in this research, generated measurable influences if mediated by Recognition and Action. Mediation by both risk reduction phases had negative influences on the occurrence of safety incidents and positive influences on the Sense of Safety. These findings suggest

6 The survey indicators related to these leadership orientations are presented in the 'Concluding taxonomy of classification of leadership indicators' (ref.7.4).

7 Dweck (2012).

that Process-oriented leaders affect safety positively, in both a direct and in a mediated way.

Relation-oriented leaders (described in Section 2.3.6.2) are good at dealing with their followers.[8, 9, 10] The safety of the primary processes of organisations is not in good hands with these leaders, however. The SEM path analysis revealed that safety incidents are not likely prevented under Relation-oriented leaders, and that there was no notable influence on their followers' Sense of Safety. The same is true of their direct influences on future potential risks. When mediated by any risk reduction phase, leaders with a Relation orientation had negligible influences on Safety.

Production-oriented leaders (described in Section 7.2.3.1) are primarily focused on quantitative production targets; safety is given little priority by these leaders.[11] Safety incidents are likely to occur under their leadership. There were no measurable influences on the Sense of Safety of their followers or future potential risks. When mediated by the risk reduction phases, Production-oriented leaders had negligible influences on Safety.

Dominance-oriented leaders (described in Section 2.3.6.3) were identified as ego-centric leaders; they are considered the most dangerous group where safety incidents are concerned.[12] The leadership of dominant leaders has no influence on their followers' Sense of Safety. The respondents working for dominant leaders were found to actually expect potential future safety risks in their organisations. When mediated by the risk reduction phases, dominant leaders have no influences on Safety at all.

Direct versus mediated influences

The SEM path analyses concerning the influences of the Safety Leadership orientations on Safety revealed that the presumed mediated influences were overestimated. The standardised regression coefficients of the direct influences between Safety Leadership orientations and Safety proved much stronger than the coefficients related to the mediated influences. This phenomenon applies to both positive and negative influences. Based on this finding we conclude that personal relationships between leaders and followers are strong indicators of the influence of Safety Leadership.

According to the feedback of our participants/respondents in this research, the Risk Reduction Cycle is a highly representative and useful model of the risk management process. Mediation by risk reduction phases, however, has a detrimental influence on the relationship between Safety Leadership and Safety. This discovery leads to the conclusion that Risk Reduction Capacity may serve as a useful indicator of the influence of risk

8 McClelland (1967).
9 Pardey (2007).
10 Yukl (2010).
11 McClelland (1967).
12 Post (2004).

management activities, but that this does not necessarily imply that mediation by risk reduction results in notable influences between Safety Leadership and Safety.

The only notable mediated influences were those on Safety by Process-oriented leaders, mediated by the Recognition and Action risk reduction phases. This finding suggests that these risk reduction phases can be considered the two phases most related to safety risks: Recognition identifies potential problems and remedial Action solves the problems. The Ability, Motivation and Courage risk reduction phases serve a more supportive or intermediate role, facilitating the quality of the risk reduction process ultimately leading to the Action phase, but with no autonomous influence on Safety.

A table showing all identified standardised regression coefficients concerning the influences of Safety Leadership on safety is presented in Appendix 15.11.

10.3.3 *Operational applicability of the Safety Leadership Survey*

During the reflective sessions in which we presented the organisations' survey results we obtained much feedback on these results. Most of the times this feedback included recognition and confirmation of the presented survey results by all hierarchical levels.

Often senior leaders in subject organisations expressed their satisfaction with the survey outcomes and confirmed useability of the survey method, especially for internal human resources considerations.

> Senior managers and directors who are often studied in relation to business successes, may be regarded as a neglected species when it comes to safety performance.
>
> RHONA FLIN

11 Conclusions and recommendations

11.1 Conclusions

Introduction

In the following sections we present our conclusions about the pre-research available knowledge, such as the theories, concepts and phenomena used to develop our research model. These are referred to as 'Known-knowns' in Section 11.1.1. We then enter the area of risk reduction, wondering where organisations are strong and weak where the incident prevention process is concerned. We developed a Risk Reduction Cycle to clarify this. We developed a Safety Leadership Model in order to determine how organisational leaders relate to risk reduction and to safety. This model, in combination with the Risk Reduction Cycle, enabled us to resolve the principal research query: "Can leaders of organisations help to prevent safety incidents?" Preceded by our findings about risk reduction and about a leader's influence on safety, the resolution to this principal research query is presented in Section 11.1.2. We have called this section 'Unknowns Revealed'.

11.1.1 *Known-knowns*

In this study the 'known-knowns' pertain to a comprehensive treatise of relevant behavioural theories explaining why people behave as they do in an organisational setting, the role of leadership and the influence of situational context on employee behaviour. We also discussed contemporary risk management concepts and theories. Amongst other things, we addressed the complexity of different organisational requirements acting in different, sometimes opposite, directions, as vectors in one integrated system. The 'uncertainty' phenomena and the 'precautionary principle' have emerged prominently as counterweights in finding a stable and responsible balance for the types of effort required to make the primary process safe, and how a leader should behave in this dynamic context. We developed our research model on the basis of these theoretical known-knowns, as explained in Chapter 2, Theory, Concepts and Context.

11.1.2 *Unknowns revealed*

In search of the role of leaders in the prevention of safety incidents, we first determined the process required to prevent safety incidents. This led to the development of a Risk Reduction Cycle. According to this model five phases have to be completed in order to effectively reduce safety risks: the recognition of risks, ability to intervene, motivation to intervene, courage to intervene and timely taken remedial Action. We then determined four leadership orientations: Relation-, Process-, Production- and Dominance-oriented leaders. We developed a set of survey indicators so as to be able to label each leader with a specific leadership orientation.

Finally, we developed a Safety Leadership Model, consisting of three nodes: the five risk reduction phases, the four leadership orientations, and a node representing the respondents' perceptions of safety (Event History, personal Sense of Safety and Risk Potential). We determined the relationships between risk reduction, leadership orientations and perceived safety through five different lenses: an online prospective survey, reflection on the survey outcomes by senior leaders, a retrospective analysis of the contribution of leaders to safety incidents, interviews with risk analysis experts, and a review of incident investigation reports by the Dutch Safety Board. We uncovered a wide variety of previously unknown data, and resolved the principal research query.

In this section we present a summary of the relevant revealed unknowns.

11.1.2.1 Risk Reduction Capacity

With respect to the risk reduction related outcomes of this research, the data analysis shows that in general employees are overly optimistic where the recognition of safety risks is concerned. This outcome was derived from the information obtained from incident analysts and risk analysis experts, who report that the recognition of risks is the weakest link in the risk reduction process, aimed at preventing serious safety incidents. We also found that timely remedial Action appears to be a weak link in the risk reduction process phase; the data analysis shows that remedial Actions are either not implemented, or not implemented in a timely manner.

We also discovered that in general employees are intrinsically motivated to intervene when safety risks have been recognised, but the ability and courage of employees to intervene when safety risks have come to their knowledge did not appear to improve the process from the recognition of safety risks to remedial Actions.

Analysis of the data by individual business sectors revealed that respondents working in the process industry are reluctant as regards having the courage to intervene. Nevertheless, if and when safety risks have become obvious, remedial Action is taken in a timely manner. The respondents working in the sector where, more than in other businesses, the individual safety of the respondents themselves is at stake (the oil and gas industry), delivered the highest scores where the recognition of risks and timely remedial Action are concerned. In the general infrastructural sector, the employees reported that safety risks are well recognised and that remedial Action is taken in a timely manner, but on an operational level this sector indicates little courage to intervene, suggesting that the employees are somewhat optimistic where the efficacy of remedial Actions is concerned. An analysis of the data delivered by the business sectors not mentioned above did not reveal results that were different from average.

We discovered that respondents in higher hierarchical positions in organisations returned relatively high scores. This indicates that managerial respondents have a more favourable view regarding the state of safety in their organisations than the lower ranked employees. Support staff members (i.e., HSEQ staff) were clearly the most critical population where the Risk Reduction Capacity of their organisations is concerned. This group returned the lowest scores of all hierarchical levels.

11.1.2.2 Leaders' influences on safety

The outcomes of this research suggest that leaders can indeed help to prevent safety incidents, but not all leaders are equally influential in this respect. The different orientations of leaders have different influences on the Risk Reduction Capacity of organisations and thereby on the level of safety in organisations. The effectiveness of a leader with respect to the prevention of safety incidents therefore depends a great deal on their specific leadership orientation.

Based on the outcomes of this research, we found that Process-oriented leaders, as the only leaders who actively contribute to the prevention of safety incidents and who increase the Sense of Safety of their followers, may be considered 'safe' leaders. Production-oriented leaders were primarily focused on their production targets and maintained a (sometimes intuitive) decisive way of leadership. At times these leaders are known for following their gut feeling and then even ignoring formal procedures. Relation-oriented leaders were identified as a predominantly social group.

Where safety is concerned, however, Production- and Relation-oriented leaders have to be watched closely in order to prevent work practices that may prompt safety incidents, because Production-oriented leaders seek mainly to achieve production targets and Relation-oriented leaders may demonstrate a laissez-faire type of leadership, leaving their teams too much freedom.

Dominant leaders are considered status-addicted individualists, who have no respect for their co-workers. In relation to the other leadership orientations, dominant leaders can be seen as an extreme form of Production-oriented leader, and also as the opposite of Relation-oriented leaders. Dominant leaders are therefore to be considered a 'safety aversive' group, who should not be selected to lead primary processes involving safety risks.

Taking the survey indicators defining a Process-oriented leader into account, we argue that leaders who motivate their followers to intervene when safety risks appear, who can forgive people when they do this needlessly (by mistake), who ensure that necessary improvements are made and who credibly convey the message that operational safety is their top priority, are the best candidates for success in preventing safety incidents.

11.1.2.3 Resolution of principal research query

> On the basis of the above statements, we conclude that the prevention of safety incidents in organisations is best served by Process-oriented leaders, who focus on the Recognition of risks and ensure timely remedial Action.

The principal research query of this research "Can leaders of organisations help to prevent safety incidents?" is resolved according to the above statement.

In this section we presented the 'known-knowns', which were reconfirmed by this study, and the 'revealed unknowns', which were new discoveries made by this study concerning the relationship between leadership and safety. We concluded this section with the resolution of the principal research query.

We continue our dissertation with an overview of recommendations, intended to foster Process-oriented leadership in order to improve operational safety.

11.2 Recommendations

Introduction

This research delivered evidence about known and unknown aspects of the role of leaders in the prevention of safety incidents.

As described in Section 11.1.2.3, the resolution of the principal research query, reads as follows: 'The prevention of safety incidents in organisations is best served by Process-oriented leaders, who focus on the Recognition of risks and ensure timely remedial Action'. Subsequent to this, leaders are expected to follow behavioural characteristics such as:

- Sincerely caring for safety;
- Ensuring that necessary improvements are implemented in a timely manner;
- Motivating team members to intervene to prevent safety incidents;
- Forgiving people who intervene by mistake.

Leaders with these behavioural characteristics are called Process-oriented leaders.[1]

These leaders are considered able to create a sustainable context in which their teams are enabled to safely conduct their operational tasks. In our role as researchers, we consider it our obligation to develop and present a set of recommended leadership principles in order to support Process-oriented leaders in their responsible duty. In the next sections we will explain the development process of our recommended Process-oriented Safety Leadership Principles, aimed at the board room level of organisations.

To broaden the scope of our development process, we use four academic safety lead-

1 The behavioural characteristics of Process-oriented leaders are derived from the 'Concluding taxonomy of classification of leadership indicators' (ref. 7.4).

ership concepts, which we consider helpful to foster Process-oriented leadership. We then summarise the recommendations derived from these concepts. After that we discuss the results of two empirical research studies, which we believe complement the outcomes of our research. Next, we present our recommended set of Process-oriented Safety Leadership Principles. Finally, we present our recommendations for external parties, that is, governmental inspectorates, certifying authorities and safety training institutes.

11.2.1 *Fostering Process-oriented Safety Leadership: the academic approach*

In the next sections we discuss four theoretical leadership concepts: High Reliable Organizing, Psychological Safety, Growth Mindset and Transformational Leadership. Thereafter, in Section 11.2.1.5, we present a summary of four recommended Academic Safety Leadership Practices as derived from these theoretical concepts.

11.2.1.1 High Reliable Organizing[2, 3, 4, 5]

In High Reliability Organisations (HRO's) the term 'collective awareness' serves as the master key. With this key, albeit a container term, organisations are considered able to discover unknown potential hazards and to manage the involved risks *optima forma*. Although container terms are useful to describe the scope of a concept they are of little use to leaders, who are faced with the challenges of day-to-day operations and need to know what to do in order to increase this awareness in their teams. We will therefore translate 'collective awareness' into relevant, operationally applicable proposals, which, if implemented, foster the Process-oriented qualities of leaders. We refer to observed similarities in the behaviours of Process-oriented leaders and the HRO principles as described in Section 7.2.3.2.

The HRO principles "preoccupation with failure", "reluctance to simplify interpretations" and "focus on operations" relate to the survey indicators 'considering operational safety as top priority' and 'motivating followers to intervene in case of suspected safety risks.' The principle "deference to operational expertise" refers to respect for competence on an operational level, which is in alignment with our survey indicator about 'forgiving followers after they have mistakenly interrupted operations for safety reasons.'[6] According to Weick and Sutcliffe, the 'operational expertise' qualification should be interpreted as "an assemblage of knowledge, experience, learning and intuition that is seldom embodied in a single individual. Even if expertise appears to be confined to a single individual, that expertise is evoked and becomes meaningful only when a second person re-

2 Weick and Sutcliffe (2007).

3 Groeneweg (2019).

4 De Bruine (2018).

5 Slagmolen, Van Dalen and Tolk (2017).

6 Regarding this HRO principle we refer to Hopkins, who argues that leaders "... should be sensitive to experience of frontline operators, encouraging them to speak up."

quests it, defers to it, modifies it, or rejects it." A positive response to, possibly false, safety alarms raised by low ranked personnel in particular, is where Process-oriented leaders show their mindfulness and where their leadership stands out from other leadership orientations. The HRO principle "commitment to resilience" is closely related to our survey indicator 'ensuring implementation of required improvements'. Weick and Sutcliffe explain: "The essence of resilience is the intrinsic ability of an organisation to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress."

Primarily, we propose that leaders dare to discuss normalised deviant behaviour with their followers. We refer here specifically to differences between 'work-as-intended and work-as-done', for example working according to self-invented work practices, deliberate non-compliance with procedures, or skipping procedural steps (short cuts). In a study into the motives of employees who deviate from agreed work procedures, Hudson et al. found that more than 70% of procedure-violating employees do this because they consider their violation a way to increase the efficiency of the work; they violate the rules for the company's benefit, trying to contribute positively to the production process.[7]

Associated with the previous proposal, leaders should not avoid debates about the (ignorance of) seemingly unimportant deviations from normal, also known as 'weak signals.' These signals may appear as feelings, such as being surprised, puzzled or anxious about something not looking, sounding, or smelling as it normally does. Trust those feelings! They are a solid clue that something is really wrong. Do not ignore them, and investigate their origin, before continuing your planned course of action.

'Hidden' risks are of a different nature, and seemingly have nothing to do with operational safety. As superficially 'normal', but latently risky examples, we note personnel changes in operational staff, supervisors or management; understaffing; changes in delegated responsibilities; and changes in contracts with third parties. These merely administrative changes, are not always associated with possible operational disturbances, however, they could have a tremendous negative impact on the stability of primary processes.

More closely associated with operations, we propose to identify whether there are variances in operation procedures between departments, sites or time periods (e.g., days/nights, weekends, holidays). There are probably good reasons for these differences, but inexplicable differences should be noted and investigated. In this respect, leaders should create a climate in which open dialogue is easily facilitated between all relevant operating and supervisory staff in order to determine why the identified differences exist. With respect to Process-related communication, leaders should be alert concerning team members who are often absent when it comes to evaluating, reflecting and learning.

Concerning risks specifically associated with organising work processes, leaders should realise that 'plans create blind spots.' Weick and Sutcliffe state "The problem with blind spots is that they often conceal small errors that are getting bigger and can produce disabling brutal audits." We therefore propose that leaders be aware and respect this type

7 Only a very small minority (±15%) violates rules for personal comfort or individual benefit.

of risk, and also motivate their team members to take this into account during their operations. In general, we propose that when anyone, rightfully or not, waves a red flag, suggesting that a safety risk is apparent, leaders should respond positively, should verify the message and be prepared to take all remedial actions needed to prevent escalation in a timely way.

These proposals to foster Process-oriented leaders can be summarised in the following: "Expect the unexpected and always assume that during operations something can go wrong!"

11.2.1.2 Psychological Safety[8, 9]

The requirement to create a psychologically safe environment (referred to by Edmondson as a 'Fearless Organisation'), may be considered an important quality in a Process-oriented leader. Psychological safety develops an atmosphere of mutual respect across people of different hierarchical status and disciplines, predicts engagement in safety activities, and is a key antecedent of speaking up and learning behaviour in teams. Engagement, as physically, cognitively and/or emotionally connected, is essential for overcoming powerful barriers to safety improvement

As a material intervention we note 'leader inclusiveness', which means the 'words and deeds exhibited by a leader that indicate an invitation and appreciation for others' contributions.' This directly pertains to situations characterised by status or power differences, and pertains more narrowly to behaviours that invite and acknowledge the views of others. Leader inclusiveness helps cross-disciplinary teams overcome the inhibiting effects of status differences, allowing members to collaborate in process improvement. Leader inclusiveness helps to include others, through direct invitation, in discussions and decisions in which their voices and perspectives might otherwise be absent. But there is a pitfall noted: without mutual respect and sincere appreciation, the initial positive effects of being invited to provide input will be insufficient to overcome the hurdle presented by status boundaries.

Building psychological safety is a threefold process: setting the stage, inviting participation and responding productively. The recommended leadership tasks and objectives, plus the related interventions for these stages are explained below.

Setting the stage (objective: shared expectations and meaning)
Frame the work; set expectations about failure, uncertainty and interdependence to clarify the need for voice; emphasise purpose; set the tone from the top; identify what is at stake, why it matters and for whom.

8 Nembhard and Edmondson (2006)
9 Edmondson (1999)

Inviting participation (objective: confidence that voices are welcome)
demonstrate situational humility; acknowledge gaps; practice enquiry; ask purposeful questions; model intense listening; set up structures and processes; create forums for input; provide guidelines for discussion

Responding productively (objective: orientation toward continuous learning)
express appreciation; stimulate blameless reporting; listen, acknowledge and thank; destigmatise failure; look forward; offer help; discuss, consider and brainstorm the next steps; sanction clear violations

11.2.1.3 Growth Mindset[10, 11, 12]

Process-oriented leaders show behaviours belonging to a Growth mindset. People with a Growth mindset are constantly monitoring what's going on. They are sensitive to positive and negative information, but they are attuned to its implications for learning and constructive action. They question themselves: What can I learn from this? How can I improve? How can I help others do this better?

People are not static beings; everybody can grow if their leaders stimulate and value personal development and the growth of employees. Growth-minded leaders believe in human potential and development, and they show that they do. Instead of using the organisation as a vehicle for their greatness, they use it an engine of growth for themselves, the employees and the company as a whole. Don't talk royalty, talk journey. Growth minded leaders nurture employees by visiting factories and having frequent chats with front-line employees. These leaders are obliged to make these visits and comply with visit schedules by blocking time slots in their diary. They also emphasise that everyone is part of a team by limiting the use of the words 'I' and 'me'; using 'we' and 'us' instead. Self-confidence is "the courage to be open and to welcome change and new ideas regardless of their source." When things have not gone as expected: be understanding and supportive, help people through and be a guide, not a judge.

When selecting and hiring people, leaders should focus more on a candidate's mindset and less on their pedigree. A resume doesn't say much about 'inner hunger': look for people who are filled with passion and a desire to get things done. A Growth-minded leader opens up dialogue and channels for honest feedback; they asks their team members what they like and dislike about the company, and what they think needs changing. This is also typical behaviour for a Process-oriented leader. Where people show self-importance, shut down elitism. Dare to clean up and get rid of brutal 'bosses'; foster productivity by mentoring, not by authoritarian terror. When new ideas prove to work well, don't reward the single originator of the idea, but reward the team that brought the idea

10 Dweck (2012).
11 Dweck (2016).
12 Ruijters and Simons (2012), pp. 399–407.

to fruition; reward teamwork rather than individual genius. As a consequence, leaders will share the credit with their teams rather than take the full credit themselves. Management and supervisory team meetings are not 'centres of expertise', so when expertise is required Growth-minded leaders support collaboration across organisational boundaries, ignore hierarchy, and invite input according to the operational competence and experience of all relevant disciplines.

11.2.1.4 Transformational Leadership[13, 14, 15, 16, 17]

Above all, transformational leadership is distinguished by the possession of a moral core. With reference to our research project, this core is 'safety'. This also applies to Process-oriented leaders. Transformational leadership is determined around the four so-called 'leadership dynamics': idealised effect, inspirational motivation, intellectual stimulation and individualised consideration. These four leadership dynamics are related to workplace safety, and transformational leadership is, among other things, associated with psychological safety, work motivation and unit performance. Leaders who challenge their subordinates to work towards a collective goal of safety are considered to have the quality of 'inspirational motivation'. These leaders are able to intellectually stimulate their subordinates to think about novel and innovative ways to adhere to safety. Leaders with high levels of the 'idealised effect' leadership dynamic are, like Process-oriented leaders, more likely to focus on the long-term benefits of safety goals rather than a short-term focus on productivity pressures. As regards proposing useful interventions to foster Process-oriented leadership, we refer to Zohar and Luria, who studied a specific and successful intervention method in which Process-oriented leadership plays a key role.

In three intervention studies designed to modify the supervisory monitoring and rewarding of subordinates' safety performance, Zohar and Luria argue that supervisory-level interventions should be expanded to the transformational leadership dimension. These scholars suggest that the hierarchical nature of organisations allows for behavioural safety interventions at the supervisory level, that is, above the shop-floor level where injuries may occur. This implies that complementary interventions can be conducted concurrently on several hierarchical levels. The organisational context must be well integrated in intervention programs, taking into consideration that changes taking place at any hierarchical level must be supported by concomitant change at other levels in order to maintain change over time. For instance, senior managers in the air traffic management industry indicated that a flatter organisational hierarchy fosters a stronger sense of leadership effect, because it creates a better flow of communication between leaders and subordinates.

13 Zohar and Luria (2003)
14 Zohar (2002)
15 Bass and Steidlmeier (1999)
16 Wong, Kelloway and Makhan (2016)
17 Gregory Stone, Russell and Patterson (2003)

Intervention models must assume a multi-level perspective, because processes take place at any organisational level and are affected by adjacent levels, that is, processes at different levels are interconnected. This implies that cross-level effects must also cover a third hierarchical level, because changes in supervisory practice must be supported by higher management, that is, the intervention must involve, at least, two layers of management in order to ensure maintenance of change.

Whereas conventional behaviour-directed interventions often depend on external observers to provide feedback and deliver incentives, effective supervisors obtain the same information and deliver incentives as part of their daily routine. For example, an effective Process-oriented leader would observe whether work on a difficult task is performed properly and express approval or disapproval immediately thereafter.

The specific intervention implemented in these studies encompassed weekly feedback to line-supervisors concerning the frequency of safety-oriented interactions with subordinates.

Supervisory-level intervention consisted of providing weekly personal feedback to line supervisors, accompanied by the communication of (high) safety-priority from direct superiors (i.e., operational/department managers). Feedback concerned randomly timed episodic interviews with subordinates. During interviews, workers described their most recent interaction with their supervisor.

It is important to emphasise that incentives delivered by superiors (e.g., personal attention and recognition) have consistently been shown to provide the strongest reinforcement value in the organisational context, surpassing material and social incentives. Zohar and Luria reported that their results indicated a change in supervisory safety practices (i.e., frequency of safety-oriented interaction with subordinates) over a short period, from a baseline rate of 9% to a new plateau averaging 58%. This, in turn, resulted in a significant decrease in minor injury rates. Continued improvement during the post-intervention period suggests that managerial policy concerning the role of line supervisors in behavioural safety was modified, and long-term effects were expected.

11.2.1.5 Summary of Academic Safety Leadership Practices

Albeit in different wording, the theoretical concepts (High Reliable Organizing, Psychological Safety, Growth and Transformational Leadership) as presented above are in many ways complementary, and are not incompatible. All descriptions of these concepts show elements of multiple analogous subjects, are objectively aligned, and unvaryingly concern the development of Process-oriented behaviours. Within these concepts we observed a series of safety leadership practices, a summary of which, catalogued by the four characteristics of Process-oriented leaders (sincerely care for safety, ensure that necessary improvements are implemented timely, motivate team members to intervene to prevent safety incidents, forgive people who intervene by mistake[18]) is shown below.

18 The behavioural characteristics of Process-oriented leaders are survey indicators included in the 'Concluding taxonomy of classification of leadership indicators' (ref. 7.4).

Re. Sincerely care for safety

a. Showing exemplary behaviour in relation to safety by demonstrating situational humility by acknowledging gaps in own performance.
b. Framing of work by setting clear expectations about failure, uncertainty and interdependence to clarify the need for voice.
c. In selection and hiring processes, looking for people who are filled with passion and a desire to get things done. Shutting down elitism and getting rid of brutal 'bosses'; fostering productivity by mentoring. Talking about the journey, instead of royalty, limiting use of the words 'I' and 'me'; using 'we' and 'us' instead.
d. Showing that the organisation values and stimulates the personal development and growth of employees.
e. Fostering open dialogue by:
    i. Opening up dialogue and channels for honest feedback; asking team members what they like and dislike about the company and what they think needs changing, for example by setting up structures, processes and forums for input, and providing guidelines for discussion.
    ii. Supporting collaboration across organisational boundaries by inviting input from people with relevant operational competence and experience in all meetings and consultations, ignoring hierarchy and departmental barriers.
    iii. Welcoming change and new ideas regardless of their source;
    iv. Including all team members, through *direct invitation*, in discussions and decisions in which their voices and perspectives might otherwise be absent;
    v. Daring to discuss identified normalised deviant behaviour.
    vi. Not avoiding debates about the (ignorance of) seemingly unimportant deviations from normal, also known as 'weak signals.
    vii. Leaders be aware and respect that unknown risks (blind spots) may exist and also motivate their team members to take this into account during their operations.
f. Maintaining an effective policy concerning compliments and incentives:
    i. Rewarding teamwork rather than individual genius.
    ii. Rewarding people who report (perceived) safety risks by ensuring that all reports are analysed, decisions on remedial actions taken, and that the people reporting them receive feedback on actions taken (even if that feedback is to explain the reasons for a lack of action).
    iii. Delivering incentives as part of the leader's daily routine, for example weekly feedback to line-supervisors concerning the frequency of safety-oriented interactions with their subordinates, accompanied by the communication of high safety priority from direct line management and feedback from randomly timed episodic interviews with subordinates, in which workers describe their most recent interaction with their supervisor.
    iv. Ensuring that incentives delivered by superiors (e.g., personal attention and recognition) consistently provide the strongest reinforcement value in the organisational context, surpassing material and social incentives.

Re. Ensure that necessary improvements are implemented in a timely manner

g. Stimulating reporting of safety risks and operational disturbances, expressing appreciation by listening, acknowledging, responding positively, verifying the message and being prepared to take all remedial actions needed to prevent escalation in a timely way.
h. Identifying whether there are variances in operation procedures between departments, sites or time periods (e.g., days/nights, weekends, holidays), initiating an open dialogue between all relevant operating and supervisory staff in order to determine why the identified differences exist, and acting on findings.
i. Considering that changes take place at any hierarchical level, intervention initiatives must be supported by concomitant change at other levels, because processes take place at any organisational level, and are affected by adjacent levels; that is, processes at different levels are interconnected.
j. Being alert for team members who are often absent when it comes to evaluating, reflecting and learning, and acting on findings.

Re. Motivate team members to intervene to prevent safety incidents

k. Emphasising purpose by identifying what is at stake, why it matters and for whom.
l. Conveying the message to expect the unexpected and always assume that things can go wrong during operations.

Re. Forgive people who intervene by mistake

m. Fostering a just culture by focusing on system flaws, not on individuals, but sanctioning clear violations.
n. Practicing enquiry by asking relevant purposeful questions and listening intensively.
o. Being understanding and supportive when things have not gone as envisaged, and helping employees through, acting as a guide, not as a judge.
p. Destigmatising failure through looking forward, offering help, discussion, consideration and brainstorming the next steps.

11.2.2 *Fostering Process-oriented Safety Leadership: an operational approach*

Introduction

The previous section highlighted recommended leadership practices derived from four theoretical concepts, each underpinning (elements of) Process-oriented Safety Leadership. Most of these recommended leadership practices are abstract in nature, and are only to a limited extent tuned to leaders working in operational conditions. Primary Process-focused leaders have less affinity with abstract theoretical concepts. They tend to act upon risks they assess as 'real', present at this very moment and considered a threat to their own area of responsibility. In that respect, it is important to distinguish between theoretical and applied approaches in risk assessment between a scholar's conceptual

world and a leader's real world. Van Asselt argues that recommendations may suffer from either or both of the following disadvantages:
- The recommended practices do not address the most salient uncertainties/risks; and/or
- The recommended practices are not understandable to non-scientists in general and decision-makers in particular."[19]

According to Van Asselt, in order to support leaders to behave as Process-oriented safety leaders, clear operationally focused risk-related leadership directives are needed. Nevertheless, it is considered important to realise that, with respect to the effectiveness of recommended leadership practices, there is no guarantee of success. Concerning safety, we face the constraint that it is not possible to determine an absolute 'safe-unsafe distinction'. As mentioned earlier in this dissertation, there is no universally unambiguous definition of safety (ref. 2.1.1) and the many uncertainties around the risk assessment process also do not strengthen our trust in its conclusions (ref. 2.2.3.1). Whether the recommended leadership practices, if fully implemented, will prevent all safety incidents in all organisations, also cannot be tested scientifically, simply because of the impossibility of assigning representative control groups where these practices are not implemented.

Still, our research has delivered convincing evidence that Process-oriented leaders, who focus on the recognition of risks and timely remedial Actions, have a positive effect on operational safety. We explicitly emphasise, however, that any scientific study, conducted in an operational environment *always* contains some degree of ambiguity created by the specific situations in the organisation(s) being surveyed when the data was collected (actual processes at hand, available respondents, contextual conditions, etc.). Consequently, despite the evidence offered in this research, we cannot guarantee that any recommended practice based on the outcomes of this study will lead to the prevention of *all* incidents, *anytime,* in *all* operational situations, in *every* organisation. With respect to our recommended practices, we therefore apply the well-known disclaimer: "Results achieved in the past, do not guarantee success in the future!" Despite this, where the *effect of leaders on safety* and the *effect of interventions* are concerned, data acquired in operational settings is the most representative information and therefore the most convincing approach to measure effects.

In order to develop recommendations to optimally foster Process-oriented Safety Leadership, we referred primarily to the outcomes of our research. We used the outcomes of two other empirical research studies conducted in 'real life' operational conditions as complementary sources to broaden the scope of our recommendations. These two complementary studies demonstrate two different views on safety leadership practices: a study by Flin (on the influence of management regarding safety) and a study by Hale et al. (on the effectiveness of intervention strategies). We describe the relevant selected content of these two studies below.

19 Van Asselt (2000), p. 6.

11.2.2.1 Management influence on safety (Flin)[20]

There is sufficient evidence that supervisors, site managers and senior managers all have distinctive influences on the health and safety of their co-workers. The safety culture of an organisation is determined by the perceptions of management's commitment to safety, as judged by the workforce. As in any other facet of management, it is the behaviours that are demonstrated in relation to safety that are critical. Senior management commitment is best indicated by the proportion of resources (time, money and people) and support allocated to health and safety management, and by the status given to health and safety. Time especially is a crucial factor, as it is the strongest signal of commitment by busy managers with little time to spare; if these leaders do not prioritise enough of their time to listen to safety concerns or warning signs, the primary process is at risk.

11.2.2.2 Effective intervention strategies (Hale et al.)[21]

In a scientific evaluation set up to assess the effectiveness of interventions aimed at reducing accidents, including 29 companies, Hale et al. found, among others, two discriminating factors generating enough energy to overcome the inertia against change: the contribution of the safety professional and the support of the director(s). Three of the five most successful projects were coordinated by the three most active, persistent and creative of the safety professionals encountered in this study. In companies where the support of site managers was absent or detached, the company was three times as likely to be unsuccessful, and all of the companies where that support was active and participative were successful. This study clearly showed the importance of support from safety professionals and top management as the 'engine' for the successful implementation of safety interventions. Several discriminating factors emphasised the importance of dialogue between the workforce and line-management as the most essential factor in ensuring that organisations learn and change. Central to this dialogue was reporting dangerous situations (Recognition!) The most successful companies in the study were the companies where the workforce and managers were more actively encouraged to look for safety hazards; these companies showed spectacular increases in hazard numbers. This was then seen as a sign of success (not of an increase in danger). These companies facilitated this 'hunt for dangerous situations' by providing employees and supervisors with digital cameras to record them. Above all, reporting was rewarded by ensuring that all reports were analysed, and decisions and remedial Actions taken on them (!), and that the reporters would receive feedback on actions taken (even if that feedback was to explain the reasons for a lack of action). This process encouraged dialogue about actions, which could also be pursued in toolbox meetings. As a result of this process the workforce was empowered to refuse to work under unsafe conditions, which despite management fears was used highly responsibly. Note: The complete intervention process as described

20 Flin (2003)
21 Hale, Guldenmund, Van Loenhout and Oh (2010)

above might be included as a measurable goal (KPI?) as part of the responsibilities of department or site managers.

As another intervention in this study, top and line-managers were offered safety leadership training. The companies in which top management attended this training, were distinguished as the most successful companies. The researchers (Hale et al.) suggested that top management, despite of what it may think of itself, needs this kind of training to obtain a clear vision, motivation and knowledge of what to achieve and how to do it. The evidence obtained by this study suggests that safety leadership training enables leaders to better fulfil their motivating role in energising interventions.

11.2.2.3 Proposed Process-oriented Safety Leadership Principles (Board room reality)

As mentioned in the introduction to Section 11.2.2 'Fostering Process-oriented Safety Leadership: an operational approach', leaders of organisations have no other option than to live with (and trust) the available risk assessments and their individual interpretations by the people working in these organisations. Nevertheless, where the nature and the intensity of safety measures and interventions are concerned, the leaders' evaluations and consequential decisions are conclusive. This responsibility is at the hearts of a leader's responsibility for operational safety. In this section we aim to offer optimal support for this important leadership task. We thus felt that recommending a set of Academic Safety Leadership Principles was an overly-operational approach, without the required obligation as expected from committed leaders.

Principles are about 'what things to do', *practices* are about 'how things to do'.[22] Principles are thus stronger, and are clear about what objectives should be achieved, whilst leaving room for leadership interpretation regarding how to realise those objectives. Principles require the highest degree of commitment, and the kind of strong obligation that may be both required and expected, from the leadership level of organisations. We therefore developed a set of eight recommended Process-oriented Safety Leadership Principles.

We direct our recommended Process-oriented Safety Leadership Principles to leaders at all organisational levels (Supervisory Board, Board of Directors, CEOs, managers and operational supervisors). Different leaders are expected to interpret our recommendations within the context of their different individual responsibilities in the different organisations they lead.

We concluded in our research that operational safety is best served by Process-oriented leaders, who focus on the recognition of risks and timely remedial actions (ref. 11.1.2.3). We used this conclusion as the nucleus point of reference in developing the Process-oriented Safety Leadership Principles. We also used Flin's publication[23] about *managerial*

22 The summarised safety leadership practices mentioned in Section 11.2.4, may serve as useful guidelines about 'how to do it'.
23 Flin (2003)

influence on safety (ref. 11.2.2.1) in the development of our Process-oriented Safety Leadership Principles. Flin clearly identified three criteria to be observed by senior leaders: time, money and people. For instance; by allocating sufficient time for dialogue with their workforce, leaders show their commitment to being fully informed about safety concerns or (even weak) warning signs as recognised by the operational workforce. Flin argues that if leaders don't allocate enough time to conduct this dialogue, the primary process is at risk. We concur with Flin's strong argument in our proposed Process-oriented Safety Leadership Principles. We also considered the report on the *effectiveness of intervention strategies* by Hale et al.[24] (ref. 11.2.2.2), which clearly noted the importance of the active coordinating role of top management and the importance of professional support via the safety function, in the development of our Process-oriented Safety Leadership Principles. These authors also refer to hazard identification and empowering the workforce to intervene as important areas of attention. Safety Leadership training for top management and leaders is considered an important prerequisite to optimising the effectiveness of interventions.

Taking into account: a) the behavioural characteristics of Process-oriented leaders (ref. 7.2.3.2), b) the Academic Safety Leadership Practices (ref. 11.2.1.5), and c) the findings by Flin (ref. 11.2.2.1) and Hale et al. (ref. 11.2.2.2), we recommend that organisations adopt the following Process-oriented Safety Leadership Principles.[25]

1. Don't skimp on safety;
2. Ensure a sufficient number of competent staff;
3. Enable all employees to perform their duties in a safe way;
4. Empower employees to refuse to work under unsafe conditions;
5. Arrange professional safety leadership training for all leaders at all levels;
6. Allocate sufficient time for dialogue with the workforce at their workplaces;
7. Actively encourage the identification and communication of safety hazards;
8. Monitor the implementation and achieved effects of risk reducing measures.

In order to confirm their overarching effect with respect to corporate safety, we suggest that these principles are embedded in corporate governance policies and incorporated into the corporate governance statements of organisations. We elucidate these proposed Process-oriented Safety Leadership Principles below.

1. Don't skimp on safety

Sufficient time, money and people are valuable aspects of safety. Operational safety starts with safe and reliable equipment in a safe environment, operated and maintained by competent people. Cutting costs on equipment/machinery and its maintenance re-

24 Hale, Guldenmund, Van Loenhout and Oh (2010), pp. 1026–1035

25 The specific relationships between the Process-oriented Safety Leadership Principles and their sources (the behavioural characteristics of Process-oriented leaders, the Academic Safety Leadership Practices and the findings by Flin and Hale et al.) are shown In Appendix 15.12.

sults in substandard operating, or even malfunctioning equipment. Operating staff are determined to keep primary processes running. In the event of equipment failure, operating personnel are tempted to improvise in order to ensure the continuation of critical processes. Safety functions may then be overridden and operational equipment kept running using home-made 'solutions', resulting in unsafe operations.

2. Ensure a sufficient number of competent staff
The leaders of organisations must ensure the availability of predetermined required staff levels and the related competences defined by formal competence criteria, to be observed in hiring and selection procedures. Where applicable, leaders should facilitate all staff to meet these competence criteria. Primary Process-related vocational knowledge, skills and experience are considered the primary competences required for operational and supervisory staff. Operational safety is also everybody's responsibility, so this also encompasses the safety aspects of vocational knowledge and skills. In order to ensure substantive advice, leaders should arrange for determined safety professionals, and co-operate closely with this support function.

3. Enable all employees to perform their duties in a safe way
People's safe performance requires a series of contextual conditions to be met. These include, for example, fail safe equipment that is safely operable, a sufficient number of competent workers, and the absence of error-enforcing conditions and incompatible goals. It is the leader's responsibility to ensure these conditions are optimally provided.

4. Empower all employees to refuse to work under unsafe conditions
This is probably the most counter-intuitive instruction to leaders, who face production targets, but it is the responsibility of top management to convince all employees that they are committed to preventing safety incidents 'by all means', including refusal to (continue) work under unsafe conditions. An effective way of motivating employees to intervene to prevent safety incidents is to recall examples where people intentionally, but by mistake, interrupted the primary process, after which leadership reacted in an understanding way, without any negative consequences for the employee in question. Where these kinds of experiences are not available, building trust is the only strategy to make people believe that safety is the top priority of the organisation.

5. Arrange professional safety leadership training for all leaders at all levels
All leaders, from top management to operational supervisors, should attend formal safety leadership training to obtain a clear vision, motivation, knowledge and skills of what to achieve and how to do it. This enables leaders to better fulfil their roles and to energise interventions.

6. Allocate sufficient time for dialogues with workforce at their workplaces
No aspect of a leader's task is more important than being informed about concerns, and

(weak) signals emitted by operational staff. All leaders at any hierarchical level should allocate time to meet with their operational staff in a setting which this workforce considers 'secure'. These dialogues should be held on an informal basis, as well on the basis of a structured schedule, communicated to all people who are supposed to attend these meetings. Top management should allocate sufficient time to ensure that they have sufficient opportunities to have a dialogue with operational staff about safety topics. In addition to structured meetings, intermediate walk-arounds by managers, and taking time to chat over a cup of coffee are also highly recommended.

7. Actively encourage the identification and communication of safety hazards
'Chronic unease' is the required state of mind of all leaders of organisations.

Encouraging people to find potential sources of safety incidents is crucial in order to reduce complacency regarding the recognition of safety risks. If leaders and operational staff are aligned about the reasons why and how hazard identification should be implemented, the discovery of unsafe situations may be seen as a sign of success (not of an increase in danger). Facilitating employees and supervisors with the proper tools (time, knowledge and hardware) is a key requirement. Welcoming the reporting of hazards, regardless of the source of information, will stimulate the people reporting them to inform leadership in future cases. Ensuring that all hazard reports are analysed and decisions and remedial actions are taken in a timely manner is an important motivator. Clear feedback given to the people who reported issues regarding the actions (planned to be) taken, even if that feedback is to explain the reasons for a lack of action, is a key factor of success.

8. Monitor the implementation and the achieved effects of risk-reducing measures
Where the identification of a safety hazard has resulted in a plan of action, a certain level of urgency has been determined, but the issues of the day are strong, urgency is an easily-evaporating state of mind, and planned safety measures are easily labelled as less urgent. It is common that over the passage of time identified hazards lose their perceived urgency and are even downplayed. To prevent this, it is critical to install a rigid system for recording identified hazards and capturing the preventive or remedial measures determined. The implementation and effectiveness of these measures should be monitored by top management and corrective action taken when deviations from planning are detected. Compliance with this process might be included as KPI, as part of the responsibilities of the leaders involved.

11.2.3 *Recommendations for external parties*

The Process-oriented Safety Leadership Principles as proposed in the previous section are considered key tasks and objectives for leaders in organisations, however, experience has shown that many organisations face incompatible goals. We note the 'Efficiency-Thoroughness Trade-Off'-principle (ETTO), addressing the continual conflict between producing in the most efficient way and optimally managing safety risks at the same time, as presented by Hollnagel[26] (as mentioned in e.g., Section 2.1.2.4).

Where the economy is involved, economic objectives and safety goals may interfere, exposing employees and/or local residents to safety hazards. Supervisory mechanisms, that is, regulatory and certification systems, have been installed to protect these people. Organisations operating in the Netherlands operate within these systems, and different supervisory bodies monitor (semi-) private organisations regarding compliance with the applicable safety requirements. As noted by Hale, the safety function plays a key role in the safety performance of these organisations. This requires an appropriate vocational education and training infrastructure to develop the safety professionals involved.

In conclusion, we consider it of importance that, as a minimum, supervisory bodies and safety training institutes include these eight Process-oriented Safety Leadership Principles in their supervising/educating strategies.

Next, we present our considerations and recommendations directed at the three types of supervisory/educational organisations operating in the business sectors that are the focus of this research.

11.2.3.1 Governmental Inspectorates

Every society has created a legal framework to regulate the tension between societal expectations and economically driven processes, defining the obligations, responsibilities and accountabilities of all parties involved. In the context of this research, we refer specifically to legislation issued to protect people by preventing safety incidents. Different governmental inspectorates have been established to monitor compliance with the various laws, rules and regulations. As referred to in Section 2.4.1.1, a European initiated deregulation process, ranging from a prescriptive to a goal-setting approach in the 1980s, did not lead to the intended reduction of legislation. Instead, it created a legislative vacuum. This was filled by even more extensive, newly developed accreditation and certification rules. Operational prescriptive text was replaced by, for example, requirements to set performance criteria but these leave room for interpretation, and are therefore hard to operationalise univocally. This changed European approach left the governmental inspectorates with the task of inspecting the 'administrative completeness of systems, compliance with checklist procedures and presence of related certificates.' This is entirely different to the physical verification of the effectiveness of operational safety appliances. This European-driven change in legislation meant that the roles of governmental inspectorates, and simultaneously the competence requirements of its inspectors, have changed tremendously.

Kluin[27] clearly revealed the operational effects of the change in inspection strategies in a publication entitled 'Optic compliance'. She found that, where the prevention of

26 Hollnagel (2009)
27 Kluin (2014)

safety incidents is concerned, organisations follow their own policies and prepare for governmental inspections as far as necessary to keep a valid licence to operate. In practice this means that the safety departments in organisations are charged with the task of keeping all required system documentation, incident reports and certificates up to date. Kluin wonders whether this contributes to operational safety. The prime motivation behind this work seems to be protecting organisations and their leaders from legal proceedings and prosecution. Apparently, the paper world gives people (the leaders of organisations as well as the governmental inspectors) a feel-good experience.

There is a clear gap between the inspector's paper world and the leader's real world; governmental inspectors dealing with printed paper, organisational leaders dealing with the day-to-day reality of risk management. Still there is a point where they meet: the continuation of business. Safety departments keep systems and records up-to-date, to prevent a compulsory shut down by governmental authorities. In the case history involving the shutdown of tank storage in the Rotterdam area, referred to in Section 2.4.1.4, governmental inspectors detected a lack of administrative compliance (reporting of incidents). This led to a next-level physical inspection, discovering many effective safety appliances, resulting in a prohibition on continuing operational activities. In that particular case, a failure to keep administrative systems up-to-date, resulted in serious liabilities and economic losses. Moreover, this experience triggered multi-departmental governmental inspections across the entire tank storage sector, which revealed a serious number of shortcomings in many similar organisations. Reporting safety incidents and keeping paperwork up-to-date has proven to be an essential task in preventing the discontinuation of business.

But this 'success story' of a governmental intervention required a tremendous workforce from different governmental departments, which cannot easily be repeated in organisations with more complex primary processes. Governmental inspectorates simply lack a quantitatively and qualitatively sufficient and competent workforce.

A lack of available and sufficient competent experts, means that physically monitoring the safety of their complex primary processes is impossible for all business sectors involved in this study.

With this in mind, we believe that the efficiency of governmental inspectorates, in their role as the protectors of people, and the general public, who, either as employees or as hospital patients, are exposed to safety hazards, is below the level expected by society. We thus believe that these inspectorates require a different modus operandus. We believe that they would be more 'safety-effective' if they shifted their focus from system descriptions and other safety-related paper markers to different observable indicators of the safety of the real world of organisations.

Based on the outcomes of our research and taking the above into account, we recommend that governmental inspectorates consider adopting our proposed Process-oriented Safety Leadership Principles as a reference framework to be incorporated in their inspection policies, evaluation criteria and executive operations vis-à-vis the business sectors they supervise.

11.2.3.2 Certifying bodies

The perceived conflict between the economy and safety often causes discussions between the owners of economic power and other parties whose interests are affected by safety risks taken by that economic power, but in some relations, safety arguments are strong enough to supersede the economist's arguments and lead effectively to reduction of risks. An interesting case is the discussion between ship owners and the insurers of their vessels.

The safety of cargo vessels has been a point of attention since the Middle Ages, and a variety of safety measures have been taken by different countries to prevent shipwrecks. It took numerous shipwrecks, and until 1890 (55 years after the initial discussions in the UK Parliament about the topic), for the UK to issue a legal requirement to paint a load line (so-called Plimsoll mark) on a ship's hull in the Merchant Shipping Act. This Plimsoll mark indicates the maximum limit to which a ship may be loaded in order to ensure sufficient freeboard and thus safely maintain buoyancy but the reason this safety indicator was finally agreed upon had nothing to do with the safety of the ship's crew members. It was the fact that the main ship insurer, Lloyd's Register, suffered excessive economic losses due to compensation paid to ship owners for insured, but overloaded and thereby sunken vessels. The fate of drowned crew members was enthusiastically used in parliamentarian discussions by the morally motivated honorary Samuel Plimsoll, but in fact the economic arguments and political effect of Lloyd's were what was decisive in implementing the rule. I took until 1930 for the Plimsoll mark to obtain international status, and for it to be agreed that the correct implementation of this important safety requirement would be verified and certified by so-called certifying bodies.

The above history reflects a lengthy negotiation process in which multiple parties with different, sometimes conflicting objectives, agreed upon safety measures to solve an otherwise unacceptable safety risk, vis-à-vis economic objectives. After successful negotiations, agreed measures are published as, for example a standard, a norm, or a code of practice. Compliance with published measures is verified by accredited certifying bodies, who after verification issue certificates of fitness or compliance with the measures. Certification may be part of a requirement by governmental authorities, or, as part of a system of self-regulation, may be based on the mutual agreement of organisations belonging to a certain business sector.

After agreement about certification criteria is reached, the negotiated final results (draft standards, norms, codes of practice) are presented to the relevant governmental authorities for acceptance. If these results meet the requirements set by these authorities, the norm, standard, or code of practice will be operationalised as a reference to comply with relevant goal setting legislation. From that moment onwards, certifying bodies replace governmental inspectorates in their monitoring role. The corresponding factor between legislation and certification is that both act as a prerequisite to carrying out economic activities.

Historically, certificates were issued to, for example, the manufacturers of electrical appliances, cars, vessels, elevators, medical equipment, and so on, but nowadays certification is not restricted to hardware systems. It extends to, for instance, the certification of safety management systems, safety cases and vocational competency in various industries and health care sectors. Its wide implementation has created an irreversible formal position for commercial certifying bodies, which operate in an attractive new market place.[28]

An actual example, is that in some business sectors organisations have embraced a certification concept based on a so-called Safety Culture Ladder. This concept was originally developed in the oil and gas industry, and further prepared for certification in the rail sector. This 'ladder' aims to improve the safety culture of organisations in order to prevent safety incidents. The method includes a system 'measuring' the level of cultural development in an organisation. The concept encompasses the induction training of leaders and the workforce to improve the organisation's safety culture. There are five different cultural levels to be achieved. The actual level achieved, is verified by trained 'Safety Culture Ladder-verifiers', who use an extensive verification reference. Upon verification, organisations obtain an official certificate recognised by the Dutch National Standardisation Institute (NEN), proving the achieved safety culture level.

In different business sectors contracting organisations require their contractors to demonstrate their safety culture level and use this as a prerequisite before these contractors are accepted to work in their business sector. Like the Plimsoll mark, this is a case of 'safety improvement driven by economic arguments.' Regardless of the actual validity of the Safety Culture Ladder concept and its pros and cons, however, we believe that both concepts (the Plimsoll mark and Safety Culture Ladder) motivate leaders and their workforce to pay attention to the safety aspects of their operations. Although one may question the difference in calibration….

As referred to in Section 2.4.1.1, the concept of certification is found in every business sector, from oil and gas to hospitals, and is always based on economic objectives. Regardless of the motivational aspect, we see the latter as a weak aspect of certification. This is due to the fact that the parties involved present the concept as a safety improvement instrument based on independent verification by independent certifiers, but all parties involved have an economic interest in the certifying process. We therefore argue that certification should be considered a commercially driven concept, where material interests inevitably play a role. Conversely, this is not the case in verification processes where governmental inspectorates play the verifying role; public inspectors have no material interest in the outcome of their inspections.

In Section 2.4.1.1., referring to the European decision to deregulate, we argued that: "…after existing prescriptive instructions were withdrawn, the transfer to goal-setting regulations has created uncertainty and unexpected room for individual solutions to safety issues. As a response to this unclear situation, the desire appeared to eliminate the indistinctness and regain clear criteria. Private organisations (certifying bodies) and industrial sectoral associations thus rehabilitated old prescriptive rules, which had been declared

28 Zwetsloot, Hale and Zwanikken (2011).

void by the government."[29, 30] As a consequence, the certification business flourished like never before. We therefore wonder whether the envisaged effect of deregulation (reducing the regulatory bourdon on organisations) really has materialised. In our view the only measurable effect is that the duty of care by governments has been shifted to a commercially driven system without effective checks and balances. We fear that this development is an irreversible one, and that governmental inspectorates have lost control for ever. For that reason, we wonder whether the policy of delegating the responsibility for safety verification to certifying bodies really contributes to improved safety in the real world. Due to this uncertainty, we refrain from recommending that our proposed Process-oriented Safety Leadership Principles should be included in certification norms and/or standards. We consider it appropriate to first conduct in-depth research into this dilemma.

11.2.3.3 Safety training institutes

The work by Hale et al. shows that a professional safety function, teamed with top management, indeed leads to better safety results. At present a great deal of education and training programmes for safety practitioners is based on compliance with laws and regulations. This has its roots in the way regulatory bodies and organisations historically viewed the safety function. Despite this, many organisations consider the role of safety practitioners a policing one, focusing on 'catching' safety violations by the operational workforce. This is in no way the contemporary role of the safety function, however; managing operational workforce is part of the leader's function. The outcomes of our research clearly show that improving safety is not about law enforcement, but about a Process orientation.

Unless a safety practitioner is recruited from an operational position in their organisation, and has enough experience on the work floor, they are not sufficiently aware of the ins and outs of the technical and psychological processes at operational level. Experienced operational leaders have much better insights into the constraints the workforce are facing, why they sometimes deviate from agreed work and safety procedures, and why this is unsafe. This requires a different, non-policing and more accommodating and interceding role for the safety function; the safety professional must be prepared to assist leaders in designing and organising, and operators in conducting operational tasks that are 'safety-smart'. In this context an effective safety professional is an inspirational, creative consultant, sometimes acting as mediator between different schools of thought, and in other instances rendering professional safety-specific advice to all levels in the organisation. The knowledge and skills required to execute this role are entirely different than the knowledge and skills that were considered important when the governmental vocational requirements for safety practitioners were defined. The safety profession needs to be reinvented in this respect.

29 Peuscher and Groeneweg (2012).
30 Walker, Throndsen, Reeves, Hudson, Croes, Dahl-Hansen, Stadler and Winters (2010).

It is recommended that safety training institutes reconsider their roles and purpose, and consequently review their curricula to deliver a different, up-to-date kind of safety professional, who is prepared to play a constructive supporting role in Process-oriented organisations.

11.2.4 *From principles to practices*

As every organisation is unique when it comes to how leaders and workforce relate to each other, suggesting ways to implement strategic recommendations, such as Process-oriented Safety Leadership Principles, is a risky manoeuvre in itself. Nevertheless, we believe that leaving this open would be an omission, and hamper the effective delivery of our recommendations to the places they were designed for: the operational departments of organisations.

Operating in an environment where prescriptive regulations have been replaced by goal setting legislation implies that the way to achieve these goals (or safety objectives) must be decided by the organisations themselves. In this research, 'principles' represent the safety objectives and 'practices' represent possible ways to reach these. Principles are designed to serve as strategic guidance, and even be considered moral directives for those leaders who are intrinsically committed to preventing safety incidents in the organisations they lead. We also argue that safety is part of the vocational DNA of truly professional leaders. For these professionals, our recommended principles should suffice as guidance on how to behave vis-à-vis their teams. Their individual appearance, combined with their professional competence and commitment to improve the safety in their area of responsibility, are fertile soil for creative implementations.

Not all leaders who are committed to achieve optimal safety will be confident about how to implement our recommended principles. These leaders may understand the objectives, the 'what' part of Process-oriented leadership, but they might need some guidance to find answers to the 'how to'-part of it.

Where our recommended principles might lack the necessary leverage to foster Process-oriented leadership behaviour, the explanatory text in Section 11.2.1 'Fostering Process-oriented Safety Leadership: the academic approach', and the related Academic Safety Leadership Practices as summarised in Section 11.2.1.5, may serve as inspirational resources.

It is up to the individual leaders in their specific strategic and/or operational environments to adopt the most applicable practices to meet their proposed principles. The above may not apply to external organisations in the same way, and different policies may be required. Our recommended principles may not match the present law-based, goal setting inspection policies of governmental inspectorates, but with reference to the outcomes of our research, we argue that implementing our recommended principles may help organisations, by fostering Process-oriented Safety Leadership, to meet the objectives as described in health and safety regulations. This is why we suggest inspectorates employ our recommended Process-oriented Safety Leadership Principles to help organisations to foster a Process-oriented leadership style. Governmental inspectorates may play a useful role by including their experiences in different organisations/sectors when dealing with organisations being inspected or audited.

We imagine it could be useful for certifying bodies to employ our recommended principles during the development processes of new or revised certification references, such as safety norms and standards, but as mentioned before in Section 11.2.3.2, we recommend more in-depth research into the possibilities around certification. Safety training institutes are expected to be able to mobilise their present development and educational qualities to assimilate the concept of Process-oriented Safety Leadership Principles in the review and design of contemporary safety professional training curricula.

In conclusion we emphasise that the implementation of safety leadership principles requires an understanding of the specific needs to reduce the safety risks of the primary processes involved. For some leaders these principles are clear, and enough to encourage them to demonstrate appropriate behaviours, but other leaders may need more guidance and support. As mentioned before, the explanatory words in Section 11.2.1 and the Academic Safety Leadership Principles in Section 11.2.1.5 may be of useful assistance for those leaders.

11.2.5 *Summary*

This research revealed the role of leaders in relation to incident prevention in organisations. In order to be authentic, we refrained from traditional leadership typologies and used different references, which we considered more appropriate for characterising leaders in relation to their behavioural orientations. The acquired data showed different effects by differently oriented leaders. As expected, Dominance-oriented leaders proved to have a negative influence on safety. Relation-oriented leaders appeared to be friendly people with no real influence where risk reduction is concerned. Production-oriented leaders were real achievers; decisive process controllers, committed to meeting production targets.

A new character emerged during our research: the Process-oriented leader. This person proved to be a dedicated safety minded leader, who fulfils their production duties in a responsible way, simultaneously taking care of the reliability of the primary process without compromising the safety of their team members. Initially we assumed that identifying risk management activities would lead to a reliable differentiation of leaders' safety performance. We thus developed a Risk Reduction Cycle, showing the risk management process through five risk management activities. Applying this model revealed that the recognition of risks and implementation of remedial actions are the weakest links. We also discovered that, with respect to safety, people are more sensitive to how their leader behaves than to their leader's influences, mediated by risk management activities.

In conclusion, we argue that this research revealed that, in spite of the generally strong focus on ability, motivation and courage to intervene by the workforce, the effectiveness of incident prevention depends predominantly on the individual behaviour of their leaders. Consequently, in order to foster Process-oriented Safety Leadership, we decided not to focus on operational safety practices to be carried out by the workforce. Instead, we deliberately emphasise the influential power of the hearts and minds of their leaders, and propose a set of Process-oriented Safety Leadership Principles, directed at the board room level of organisations and three external parties, which we consider instrumental to support organisations in implementing these principles.

11.2.6 *Still unknowns* (*further research required*)

Although much was discovered about the relationship between leadership and incident prevention in this research, there are still unknown issues for further research. We note that this research is the first of its kind, as far as these newly developed leadership orientations are concerned. Inevitably this implies hidden imperfections and unknown biases. As the first implementation of the prospective survey questionnaire, its validation is limited to one survey only. Conducting a second (or more) surveys, replacing the indicators, which were invalidated during the various analyses, with newly developed statements, validly classified by factor analysis, could improve the rigidity of the data. Another reason to re-conduct the study, is to apply the prospective survey in different business sectors in order to verify its applicability in different 'domains'.

An area of interest for exploration is the contradiction concerning the high scores for Recognition versus the expert opinions (ref. 7.3.1). Developing a more representative hazard identification method might be helpful in addressing this contradiction. Such a better method could reduce the dangerous positive bias in the actual risk levels related to primary processes, and further encourage the 'chronic unease' state of mind.

The ambiguous aspects of the concept of certification was an interesting discovery. In our attempts to discover the applicability of the Process-oriented Safety Leadership Principles, we have not been able to reach firm conclusions about the position of these principles in relation to safety-related certification. Due to the increasing societal effect of certification related to safety, we consider this an important topic for further research.

11.2.7 *Limitations*

This research was conducted within the limitations of our operational feasibility.

First, the geographical area in which this study was conducted was limited to the Netherlands. The sectorial selection for collecting the survey data was limited to six specific business sectors and one non-specific category, named 'Other'. The acquisition method, anonymously and through online questionnaires, easily opened doors to many potential respondents, however, by using this acquisition method we were restricted as regards population control.

11.2.8 *Coda*

Following the conclusions of this research, we argue that an accident-free planet is an impossible dream, because:

- High-frequency low-impact incidents will continue to occur, because, although the risks have been clearly identified, a) the potential damage is relatively limited, and therefore b) the urgency is of local (department, location, etc.) importance, and will easily make way for the 'delusion of the day' induced by economic targets, and therefore c) remedial actions are not taken, or are not taken in a timely manner;
- Low-frequency high-impact incidents (calamities/disasters) will continue to occur because people are convinced that they are aware of all the risks, but that is not always the case, as, quoting Rumsfeld, "We don't know, what we don't know",[31] and, quoting Kahneman, "Taking into account information that does not come to mind, perhaps because we have never known it, is impossible."[32]

We concur with Perrow's 1984 statement that "Risk will never be eliminated from high-risk systems, and we will never eliminate more than a few systems at best. At the very least, however, we might stop blaming the wrong people and the wrong factors, and trying to fix the systems in ways that only make them riskier."[33] As we are convinced that the application of our proposed Process-oriented Safety Leadership Principles will reduce opportunities for safety incidents in an organisational setting, we sincerely hope that this dissertation will motivate leaders at any level to embrace these principles and adopt them in their corporate governance policies from top to bottom.

31 Rumsfeld (2013).

32 Kahneman (2012), p. 277.

33 Perrow (1999), p. 4.

12 Summary

12.1 Summary in English

Introduction

This research aims to provide insights into the relationship between the way in which leaders lead organisations and the effectiveness of risk management within those organisations, particularly of safety risks related to primary (production) processes. This insight can contribute to the prevention of future safety incidents in organisations. Safety incidents in organisations have different causes and manifest themselves in different ways. The specific circumstances and the amount of energy that can be released uncontrollably determine the course of an incident, and the seriousness of its consequences. This research was conducted in organisations where safety risks, if insufficiently controlled, can lead to incidents with serious consequences. These are incidents that may result in serious personal injury, material damage, environmental pollution, the interruption of primary processes, reputational damage and even damage to the fundamental values of the organisation.

The role of leaders is widely seen an important factor in the operational performance of organisations, however, the desire to increase operational performance can have a negative effect on attention to other aspects related to operations, including safety. For that reason, we also consider leaders important actors in reducing safety risks in their organisation.

The central research question of this study is: “Can leaders of organisations help to prevent safety incidents?”

To answer this question, we developed two models; 1) A Risk Reduction Cycle, which includes a five-stage risk reduction process, and 2) A Safety Leadership Model, which includes the relationship between risk reduction, leadership and safety. These models are described below, followed by an outline of the study, its results, conclusions and recommendations.

Risk Reduction Cycle

Preventing safety incidents requires reducing safety risks. We have shown this process in a Risk Reduction Cycle (Fig. 1). This cycle comprises the following process phases: 1) Recognition: this phase refers to the awareness and acknowledgement of the risks, 2) Ability to intervene: this phase refers to the possibilities, knowledge and skills to intervene, 3) Motivation to intervene: this phase refers to the internal motivation to want to stabilise the situation, 4) Courage to intervene: this phase refers to the external motivation to dare to put safety first, and 5) Action: Corrective action refers to controlling identified risks by implementing risk-reducing measures in a timely way.

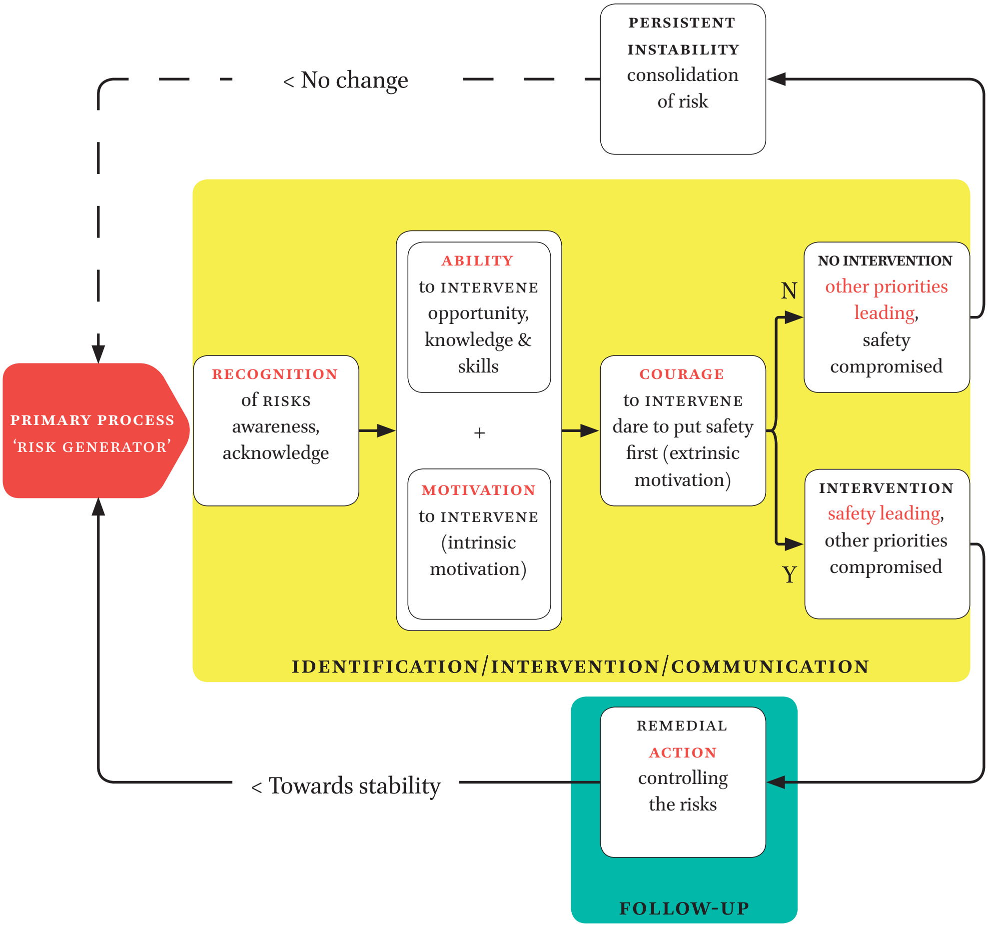


FIGURE 1 Risk Reduction Cycle

Safety Leadership Model

We developed a Safety Leadership Model to investigate the influence of leaders on safety in an organisation (Fig.2).

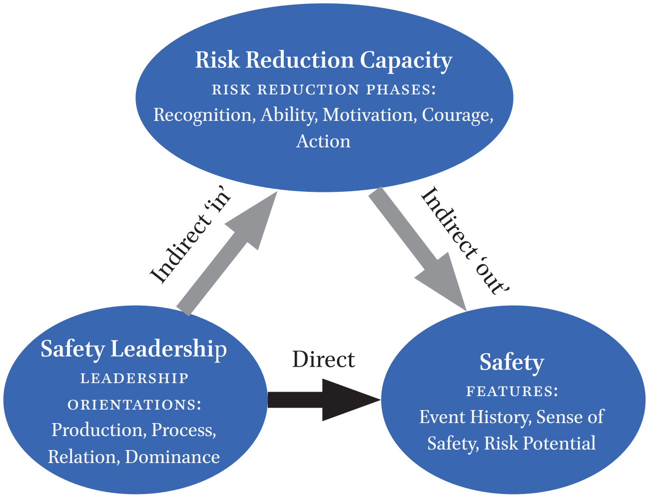


FIGURE 2 Safety Leadership Model

In this model, Risk Reduction Capacity, Safety Leadership and Safety form the three principal nodes. The arrows between these nodes represent the different ways, directly and indirectly (through Risk Reduction Capacity), in which leaders influence the safety of an organisation. This model is explained further.

Risk reduction capacity

The extent to which an organisation is able to reduce safety risks is called 'Risk Reduction Capacity'. This is determined by the extent to which the members of organisations recognise safety risks, can intervene, want to intervene, dare to intervene, and whether risk-reducing measures are implemented in a timely manner. These factors represent the phases of the Risk Reduction Cycle described above.

Safety Leadership

In this study, 'leaders' are all employees in a supervisory or managerial position. This includes, for example, board members, CEOs, directors, managers and operational executives. The way leaders behave is often referred to as their "leadership style." Leadership styles describe the conceptual principles of leadership according to certain more or less conventional leadership theories. At a more fundamental level, three underlying behavioural dimensions of leadership are mentioned; performance, affiliation and power. These dimensions refer to the different motivational strategies of leaders in relation to their subordinates. We made the choice in our research to link these theoretical strategic concepts to the safety-related aspects of the primary processes of organisations. The result of this translation is what we call 'safety leadership'. We distinguished four different leadership styles, called 'leadership orientations'. These are Relation, Process, Production and Dominance orientation. These orientations contain elements of different leadership styles as described in the leadership literature, but in order to fit in with the safety-related aspects, these orientations sometimes exceed the boundaries of these conventional styles.

Safety

We used the following characteristics in order to obtain a picture of the current level of safety in the primary (production) processes in the organisations involved in our research: 1) The number of safety incidents that have occurred, 2) The safety perceptions of employees, and 3) The perceived safety Risk Potential. The combined information regarding these three characteristics is considered a measure of the effectiveness of risk reduction in the past, present and future.

Research design

This research was conducted in organisations in the following business sectors: tank storage, hospitals, the process industry, oil and gas exploration and production, rail infrastructure, general infrastructure (roads) and a general category ('Other'). The primary processes of the organisations working in these sectors are associated with relatively high safety risks. All participating organisations are located in the Netherlands. The study on the central research question was designed as an online prospective survey, followed by reflective semi-structured interviews with senior leaders employed by the participating organisations, retrospective case history analyses, interviews with risk analysis experts and a review of incident investigation reports such as those published by the Dutch Safety Board.

Methodology

Online prospective questionnaire

In preparation for the online prospective survey, we designed a questionnaire to assess the respondents' perceptions of risk reduction, leadership and safety characteristics in the organisations in which they operate. We conducted a pilot survey to test the functionality of the Safety Leadership Model and the quality of the prospective questionnaire in terms of validity, reliability, relevance and practicality. To this end, the draft questionnaire was presented to a group of safety experts working in Dutch organisations relevant to this study. The results of this pilot survey confirmed the functionality of the model and showed that the draft questionnaire provided useful data. The safety experts also provided constructive feedback on the relevance and applicability of the questionnaire. Based on the feedback received, we adjusted the questionnaire as considered useful. From March 2016 to October 2019 the final version of the questionnaire was used to conduct an online prospective survey among the employees of all participating organisations. This survey provided valid data from 3332 respondents, working in 33 organisations, active in six specific business sectors.

Reflections by senior leaders

After collecting and analysing the survey data, we conducted a series of interviews in the participating organisations with various senior leaders, including CEOs, operations managers and safety managers, to collect their reflections on the analysis results.

Retrospective analyses of case histories

Eighteen professional incident investigators individually reviewed the analysis reports of 18 different serious safety incidents. They identified the specific leadership orientations of the leaders involved in these incidents, and identified which risk reduction phases had been compromised, allowing the subject incidents to take place.

Interviews with risk analysis experts

We conducted interviews with five professional risk analysis experts on the quality and implementation of risk assessment methods, as applied in major hazard (BRZO) organisations.

Review of literature

Finally, we studied 12 incident analysis reports from the Dutch Safety Board. We focused in particular on the way in which risk assessment contributed to the occurrence of major incidents.

Research results

Risk Reduction Capacity

This research shows that the recognition of risks (Recognition) and taking remedial measures in a timely way (Action) are the most influential risk reduction phases. The influences of the Ability to intervene (Ability), Motivation to intervene (Motivation) and Courage to intervene (Courage) risk reduction phases are limited.

With regard to the outcomes of the risk reduction research, the data analysis shows that employees are generally too optimistic about their ability to recognise safety risks. In general, once safety risks have been identified, employees are intrinsically motivated to intervene. In addition, however, the timely taking of remedial measures appears to be a weak link in the risk reduction process; the data analysis shows that such measures are often not implemented or not implemented in time. The data analysis also shows that respondents working in the process industry demonstrate relatively less courage to intervene, but if and when safety risks are clear to them, they do take remedial measures in a timely way. These measures are part of a logical risk approach in this sector, and courage is apparently not a precondition for intervention. Compared to other sectors, the respondents working in the oil and gas industry rated the Recognition of risks (Recognition) and timely remedial measures (Action) risk reduction phases highest. This indicates that respondents in this sector are particularly alert to safety risks. This may be due to the fact that there are very high safety risks in this sector, and that the respondents, who often work in remote locations, without easy escape options, are the potential victims of serious incidents themselves. In the general infrastructure sector, respondents report that safety risks are well recognised and that remedial measures are taken in a timely manner. In this sector, however, respondents at the operational level show little courage to intervene. Analysis of the data provided by the business sectors not mentioned above only yielded average results.

Our analysis sorted by hierarchical position showed that respondents in higher hierarchical positions (e.g., managers) returned relatively high scores. This indicates that managers have a more favourable view of the Risk Reduction Capacity in their organisation than employees in operational positions. The support staff (this group comprises safety and quality advisors) is clearly the most critical group when it comes to the Risk Reduction Capacity of their organisations. This group returned the lowest scores of all hierarchical levels.

Contradicting outcomes

We discovered two different contradicting outcomes during the primary analysis of the research results. The first contradiction concerns the results of the statistical analyses of the results of the online prospective survey. These results suggested that a Task-oriented leader should be considered a "safe" leader. During their reflections on the research results, many of the leaders we spoke to were somewhat surprised at this result. In their perception, an 'ideal leader' is a leader who demonstrates characteristics such as personal commitment, mutual respect, and empowerment, and someone who provides psychological safety. In our research design, however, Task-oriented leaders were regarded as achievers, who mainly focus on achieving production objectives and have little concern for the safety aspects of the primary process. There was thus a contradiction there. With regard to this contradiction, it is also interesting to refer to the views of the 18 professional incident investigators, who argued that Task-oriented leaders are not considered a safe type of leader; the researchers even cited this type of leader as the most instrumental in causing serious incidents. Based on the contradiction between the results of the prospective survey, the reflections of senior leaders and the retrospective analyses by incident investigators, we decided to take a closer look at our primary analysis.

We considered a possible error in the classification of the research indicators into the three leadership orientations. Bearing in mind the single/double loop concept (single/double loop learning), we decided to look for evidence of an (in)correctness at the source, that is, in the a priori classification of the leadership orientations (Relation and Dominance). To this end, we performed an exploratory factor analysis (EFA), and thereafter (using a different sample of the population) a confirmatory factor analysis (CFA). Both analyses showed conclusively that the a priori established leadership orientation actually consists of two significantly different orientations. Based on these analysis results, we redefined the classification of the leadership orientations and split the orientation into two new leadership orientations: Process orientation and Production orientation. This development gave rise to four (Relation, Process, Production and Dominance) instead of three leadership orientations. We adapted the Safety Leadership Model on the basis of this result.

We found a second contradiction in the analysis results of the first risk reduction phase of the Risk Reduction Cycle: 'Recognising risks'. The outcomes of the statistical analyses of the survey results show that "Risk Recognition" is considered by many respondents to be the best or the second-best risk reduction phase. This pattern applied to all hierarchical levels (leaders and followers), however, in their reflections on these outcomes, several senior leaders stated that some of the high ratings for "Recognition" (particularly by senior respondents) did not represent reality at the operational level. The retrospective analyses of case histories by the professional incident investigators even concluded that the 'Recognition of risks' should be regarded as the most compromised risk reduction phase, and that it should therefore be scored low, instead of high. This conclusion was confirmed in interviews with five professional risk analysis experts, who suggested that failure to recognise safety risks, or misunderstanding or ignoring known risks are major contributors to the occurrence of serious incidents. Moreover, the conclusions of the incident investigators and the views of the risk analysis experts were supported by the analyses of the Dutch Safety Board, which in various investigation reports notes not recognising safety risks as an important factor in the occurrence of serious incidents.

We also examined this contradiction in more detail. In doing so, we found that there are explainable different views according to, on the one hand, internal survey respondents and, on the other hand, external incident investigators and risk management experts. As a result, we have come to the conclusion that the contradictory results found here arise from the differences in perspective between the two groups, which originate from their different organisational positions, roles and operational experience. After all we are convinced that we were honestly, but differently informed by all individuals. Denying this contradiction would violate the truth, and therefore there was no reason to make adjustments here.

Leaders' influence on safety

We applied a causal path analysis (Structural Equation Modelling) to determine the influence of leaders on the prevention of safety incidents. The outcomes of this path analysis indicate that leaders affect safety in two different ways: a) through the direct influence of leadership orientations on the safety characteristics (Fig. 3), and b) through their indirect influence on the safety characteristics mediated by the risk reduction process (Fig. 4). These two different influences are shown in the figures below. In these figures, green arrows indicate the positive influences, and red arrows indicate the negative influences of the different leadership orientations on the safety characteristics. Non-significant relations found by the causal path analysis are not shown in these figures.

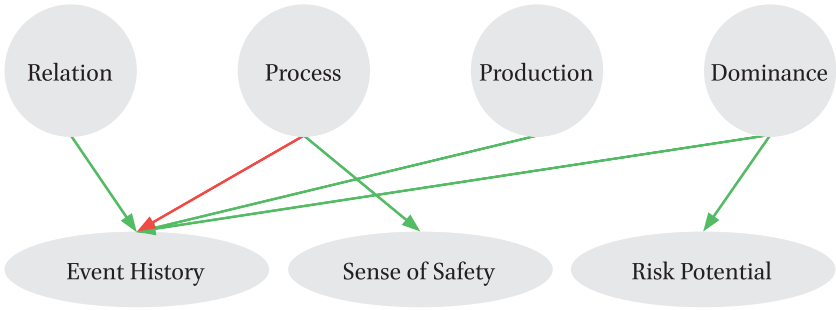


FIGURE 3 Direct influence of leadership orientations on safety

Figure 3 shows the direct influences of differently oriented leaders on the safety characteristics. In this figure we see green arrows from Relation, Production and Dominance orientations to the Event History safety characteristic. This means positive causal relationships between these three leadership orientations and the occurrence of safety incidents. A negative relationship (red arrow) was found for Process-oriented leaders, with regard to the occurrence of safety incidents. These findings suggest that safety incidents are more likely under the leadership of Relation-, Production-and Dominance-oriented leaders, than under the leadership of Process-oriented leaders. This figure also shows a positive relationship (green arrow) between the Dominance orientation and the Risk Potential safety characteristic. This suggests that employees who work under Dominance-oriented leaders perceive more potential risks than employees who work under differently oriented leaders.

As the only leadership orientation, Process orientation shows a green arrow to Sense of Safety. This indicates that employees who work under Process-oriented leaders have a positive perception of safety.

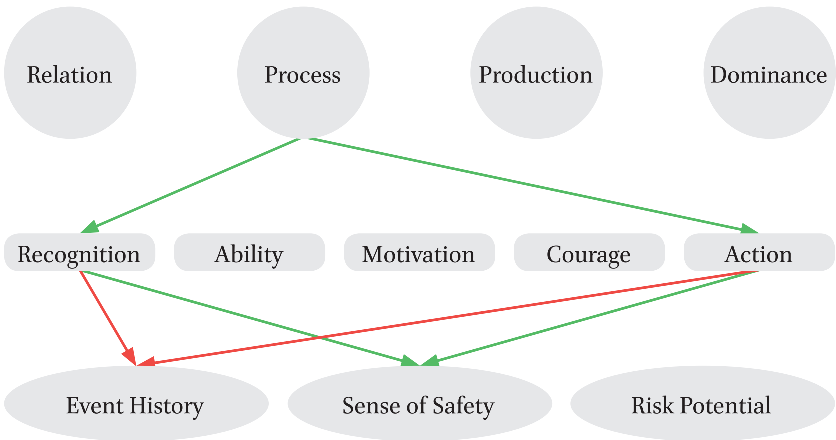


FIGURE 4 Indirect (mediated) influence of leadership orientations on safety

Figure 4 shows the indirect influence of the differently oriented leaders on the safety characteristics, mediated by the different phases of the risk reduction process. In this figure we do not see arrows from the Relation, Production and Dominance orientations, and this means that leaders with such orientations have no noteworthy indirect influence on safety (either positive or negative). There are also no arrows shown from and to the Ability, Motivation and Courage risk reduction phases. This means that these risk reduction phases are not worth mentioning with respect to the relationship between leaders and safety. No influence was also found with regard to the Risk Potential safety characteristic. The only notable influence is from Process-oriented leaders. These leaders show positive influences (green arrows) on the Recognition and Action risk reduction phases. These two risk reduction phases therefore both show positive influences (green arrows) on the safety perceptions of employees (Sense of Safety) and negative influences (red arrows) on the occurrence of safety incidents (Event History).

In summary, the results of the causal path analysis suggest that the influence of leaders on safety depends to a large extent on their specific leadership orientation. The results of the analysis of the direct influence of leaders on safety and the results of the analysis of their indirect influence mediated by the risk reduction process both indicate that Process-oriented leaders are the only leaders who a) have a positive influence on safety (Sense of Safety), and b) have a negative influence on the occurrence of safety incidents (Event History). The results of the causal path analysis of the direct relationship between leadership orientations and safety also suggest that Relation-, Production- and Dominance-oriented leaders all have a positive influence on the occurrence of safety incidents (Event History). Respondents working for Dominance-oriented leaders reported that they perceived future safety risks as real (Risk Potential).

Conclusion

Risk reduction

We have shown that employees, especially leaders, are overly optimistic about the quality of risk recognition. It has also become clear that remedial measures in response to the identified safety risks are low priority. Leaders have a more positive perception of implementation of remedial measures than operational employees.

The influence of leaders regarding safety

We conclude that Process-oriented leaders are the ‘safest’ leaders, that safety incidents are more likely to occur under Production- and Relation-oriented leaders, and that Dominance-oriented leaders are a ‘safety-averse’ group.

Based on the differences in intensity between the mediated and unmediated influence of leaders regarding safety, as found in the causal path analysis, we conclude that a good personal relationship between leaders and followers is a strong indicator of the effectiveness of Safety Leadership.

Based on the overall research results, we conclude that Process-oriented leaders, who motivate their followers to intervene when safety risks arise, forgive people when they intervene unnecessarily (accidentally), ensure that necessary improvements are made in a timely manner and who credibly convey the message that operational safety is a priority, are the best candidates for successfully preventing safety incidents.

In answer to the central research question, we conclude that: "Leaders indeed have influence over the prevention of safety incidents, and organisations are best served with Process-oriented leaders, who focus on recognising risks and ensuring the timely implementation of risk reduction measures".

Recommendations

We have developed the following Process-oriented Safety Leadership Principles based on the above conclusions: 1. Do not skimp on safety; 2. Provide sufficient skilled personnel; 3. Enable all employees to perform their task in a safe manner; 4. Empower employees to refuse work under unsafe conditions; 5. Organise professional safety leadership training for all leaders at all levels; 6. Take enough time for dialogue with operational staff at their workplace; 7. Actively encourage the identification and communication of safety risks; 8. Monitor implementation and the achieved effects of risk-reducing measures.

We recommend that leaders at all levels of organisations (Supervisory Board members, members of the Board of Directors, CEOs, directors, managers and operational supervisors) fully adopt and implement these principles in their organisations. We recommend that leaders interpret these recommendations in the context of their different individual positions, roles and responsibilities. We also propose that these principles be adopted as part of the corporate governance policy and included in the corporate governance statements of organisations.

We also consider it important that regulatory bodies, including government inspectorates and certification bodies, and safety training institutions, incorporate these Process-oriented Safety Leadership Principles into their supervisory and educational strategies.

12.2 Samenvatting (Nederlandse vertaling)

Inleiding

Deze studie heeft tot doel inzicht te verschaffen in de relatie tussen de wijze waarop leiders organisaties leiden en de effectiviteit van risicomanagement binnen die organisaties van, met name, aan primaire (productie-) processen gerelateerde veiligheidsrisico's. Dit inzicht kan een bijdrage leveren aan het voorkomen van toekomstige veiligheidsincidenten in organisaties.

Veiligheidsincidenten in organisaties kennen verschillende oorzaken en manifesteren zich op verschillende wijzen. De specifieke omstandigheden en de hoeveelheid energie die ongecontroleerd kan vrijkomen, bepalen het verloop van een incident en de ernst van de gevolgen.

Dit onderzoek is uitgevoerd in organisaties waar veiligheidsrisico's, indien onvoldoende beheerst, kunnen leiden tot ernstige incidenten. Dit zijn incidenten die mogelijk zwaar persoonlijk letsel, ernstige materiële schade, milieuverontreiniging, onderbreking van primaire processen, reputatieschade en zelfs schade aan de fundamentele waarden van de organisatie tot gevolg hebben.

De rol van leiders wordt algemeen gezien als een belangrijke factor met betrekking tot de operationele prestaties van organisaties. Echter, de wens tot verhoging van operationele prestaties kan negatieve invloed hebben op de aandacht voor andere aan de operatie gerelateerde aspecten, waaronder de veiligheid. Om die reden beschouwen wij leiders ook als belangrijke actoren bij het reduceren van de veiligheidsrisico's in hun organisatie.

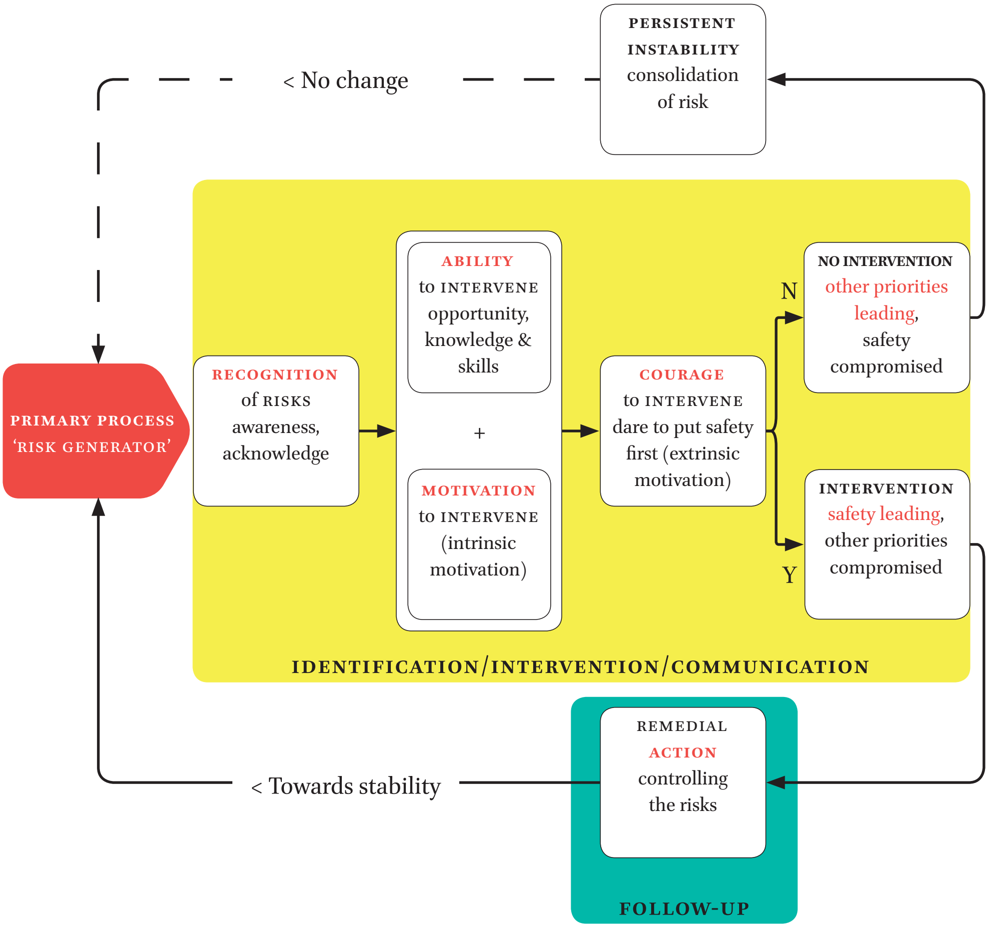
De centrale onderzoeksvraag van deze studie luidt: *"Kunnen leiders invloed hebben op het voorkomen van veiligheidsincidenten?"*

Om deze vraag te kunnen beantwoorden maken wij gebruik van twee modellen; 1. Een risicoreductiecyclus, die een vijf-fasen-risicoreductieproces omvat en 2. Een veiligheidsleiderschapsmodel, dat de relatie tussen risicoreductie, leiderschap en veiligheid omvat. Hierna worden deze modellen beschreven, gevolgd door een samenvatting van het onderzoek, de onderzoeksresultaten, conclusies en aanbevelingen.

Risicoreductiecyclus

Het voorkomen van veiligheidsincidenten vereist het reduceren van veiligheidsrisico's. Dit proces hebben wij gevisualiseerd in een z.g. Risicoreductiecyclus (Risk Reduction Cycle) (Fig. 1).

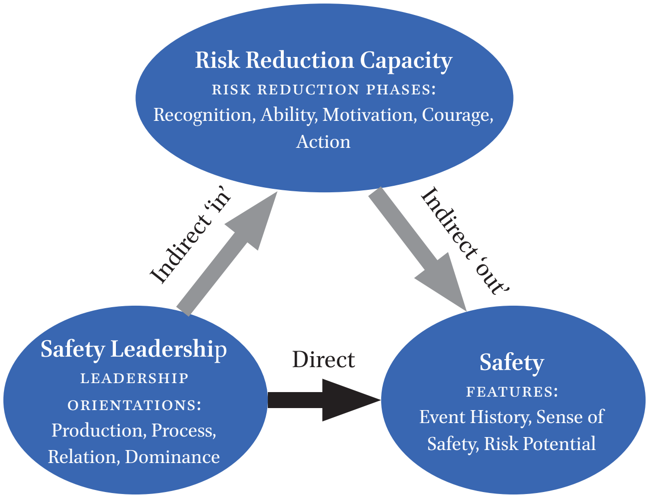
Deze cyclus omvat de volgende procesfasen: 1. Recognition: Kennen van risico's (herkenning en erkenning), 2. Ability: Kunnen interveniëren (mogelijkheden, kennis en vaardigheden), 3. Motivation: Bereidheid om te interveniëren (intrinsieke motivatie), 4. Courage: Moed om te interveniëren (veiligheid voorop durven te stellen) en 5. Action: Correctief optreden (tijdig risicoreducerende maatregelen implementeren).



FIGUUR 1 Risicoreductiecyclus (Risk Reduction Cycle)

Veiligheidsleiderschapsmodel

Om de invloed van leiders op de veiligheid in een organisatie te onderzoeken, hebben wij een veiligheidsleiderschapsmodel (Safety Leadership Model) ontwikkeld (Fig.2).



FIGUUR 2 Veiligheidsleiderschapsmodel (Safety Leadership Model)

In dit model vormen risicoreductiecapaciteit, veiligheidsleiderschap en veiligheid de drie knooppunten.

De pijlen vertegenwoordigen de verschillende wijzen, direct en indirect (via Risicoreductiecapaciteit), waarop leiders de veiligheid van een organisatie beïnvloeden. Hierna volgt een toelichting op dit model.

Risicoreductiecapaciteit

De mate waarin een organisatie in staat is veiligheidsrisico's te reduceren wordt 'risicoreductiecapaciteit' genoemd. Deze capaciteit wordt bepaald aan de hand van de mate waarin de leden van organisaties veiligheidsrisico's (her-)kennen, kunnen interveniëren, willen interveniëren, durven te interveniëren en of men tijdig risicoreducerende maatregelen implementeert. Deze factoren vertegenwoordigen de fasen van de hiervoor beschreven risicoreductiecyclus.

Veiligheidsleiderschap

In dit onderzoek worden met 'leiders' alle functionarissen in een leidinggevende functie bedoeld. Daaronder vallen bijvoorbeeld leden van raden van bestuur, CEOs, directeuren, managers en operationeel leidinggevenden. De wijze waarop leiders zich gedragen, wordt vaak 'leiderschapsstijl' genoemd. Leiderschapsstijlen beschrijven de conceptuele principes van leiderschap volgens bepaalde min of meer conventionele leiderschapstheorieën. Op meer fundamenteel niveau worden drie onderliggende gedragsdimensies van leiderschap genoemd; prestatie, aansluiting en macht. Deze dimensies verwijzen naar verschillende motivatiestrategieën van leiders in relatie tot hun ondergeschikten. In ons onderzoek hebben wij de keuze gemaakt om deze theoretisch-strategische concepten te koppelen aan de aan veiligheid gerelateerde aspecten van de primaire processen van organisaties. Het resultaat van deze vertaalslag noemen wij veiligheidsleiderschap. Daarbij onderscheiden wij vier verschillende leiderschapsstijlen, z.g. 'leiderschapsoriëntaties': Relatie-, Proces-, Productie- en Dominantie-oriëntatie. Deze oriëntaties bevatten elementen van verschillende in de literatuur beschreven leiderschapsstijlen, maar, om aan te sluiten bij de aan veiligheid gerelateerde aspecten, overschrijden deze oriëntaties soms de grenzen van deze conventionele stijlen.

Veiligheid

Om een beeld te krijgen van de actuele veiligheid van de primaire (productie-)processen in de bij ons onderzoek betrokken organisaties, hanteren wij de volgende kenmerken: 1 Het aantal opgetreden veiligheidsincidenten, 2. De veiligheidsbeleving van medewerkers, en 3. Het gepercipieerde veiligheidsrisicopotentieel. De gecombineerde informatie over deze drie kenmerken is een maat voor de effectiviteit van risicoreductie in het verleden, het heden en de toekomst.

Onderzoeksontwerp

Dit onderzoek is uitgevoerd bij organisaties in de bedrijfssectoren: tankopslag, ziekenhuizen, chemische procesindustrie, olie- en gasexploratie en -productie, algemene infra (wegen), spoorinfra en categorie algemeen ('Other'). De primaire processen van de organisaties die in deze sectoren werkzaam zijn, gaan gepaard met relatief hoge veiligheidsrisico's. Alle deelnemende organisaties zijn gevestigd in Nederland. Het onderzoek naar de centrale onderzoeksvraag is als volgt ontworpen: een online prospectieve enquête, gevolgd door reflectieve, semigestructureerde gesprekken met senior leiders die in dienst zijn van de bij de deelnemende organisaties, retrospectieve analyse van casuïstiek, gesprekken met risicoanalysedeskundigen, en bestudering van incidentonderzoeksrapporten zoals gepubliceerd door de Onderzoeksraad voor Veiligheid.

Methodologie

Online prospectieve enquête

Ter voorbereiding van de online prospectieve enquête hebben wij een vragenlijst ontworpen, waarmee wij de percepties van de respondenten omtrent de kenmerken van risicoreductie, leiderschap en veiligheid in de organisaties waarin zij werkzaam zijn, konden vaststellen. Om de functionaliteit van het veiligheidsleiderschapsmodel en de kwaliteit van de prospectieve vragenlijst in termen van validiteit, betrouwbaarheid, relevantie en praktische toepasbaarheid te toetsen, hebben wij een pilot-enquête uitgevoerd. Daartoe is de concept-vragenlijst aangeboden aan een groep veiligheidsexperts, werkzaam in voor dit onderzoek relevante Nederlandse organisaties. De resultaten van deze pilot-enquête bevestigden de functionaliteit van het model en lieten zien dat de concept-vragenlijst bruikbare gegevens opleverde. Daarbij gaven de veiligheidsexperts ook constructieve feedback over de relevantie en toepasbaarheid van de vragenlijst. Op basis van de ontvangen feedback hebben wij de vragenlijst op enkele punten aangepast. Met deze aangepaste vragenlijst is in de periode van maart 2016 tot oktober 2019 onder de medewerkers van alle deelnemende organisaties een online prospectieve enquête uitgevoerd. Deze enquête leverde valide gegevens op van 3332 respondenten, werkzaam in 33 organisaties, actief in 7 bedrijfssectoren.

Reflectie door senior leiders

Na verzameling en analyse van de enquêtegegevens, hebben wij in de deelnemende organisaties met verschillende leiders, waaronder CEOs, operationele managers en veiligheidsmanagers, evaluatiegesprekken gevoerd om hun reflecties op de analyseresultaten te verzamelen.

Retrospectieve analyse casuïstiek

18 Professionele incidentenonderzoekers hebben individueel de analyserapporten van 18 verschillende ernstige veiligheidsincidenten beoordeeld. Op basis van deze rapporten hebben zij de specifieke leiderschapsoriëntaties van de bij deze incidenten betrokken leiders benoemd en vastgesteld welke risicoreductiefasen gecompromitteerd waren, waardoor het incident kon plaatsvinden.

Gesprekken met risicoanalysedeskundigen

Daarnaast hebben wij met vijf professionele risicoanalysedeskundigen gesprekken gevoerd inzake de kwaliteit en de implementatie van risicobeoordelingsmethoden, zoals toegepast in 'major hazard' (BRZO)-organisaties.

Literatuurstudie

Tenslotte hebben wij 12 incidentanalyserapporten van de Onderzoeksraad voor Veiligheid bestudeerd, waarbij wij ons in het bijzonder hebben geconcentreerd op de wijze waarop risico-inschatting heeft bijgedragen aan het ontstaan van grote incidenten.

Onderzoeksresultaten

Risicoreductiecapaciteit

Dit onderzoek wijst uit dat herkenning van risico's (Recognition) en het tijdig nemen van herstelmaatregelen (Action) de meest invloedrijke risicoreductiefasen zijn. De effecten van de risicoreductiefasen Kunnen interveniëren (Ability), Motivatie om te interveniëren (Motivation), en Moed om te interveniëren (Courage) zijn beperkt.

Met betrekking tot de uitkomsten van het onderzoek inzake risicoreductie, laat de data-analyse zien dat werknemers over het algemeen te optimistisch zijn over de herkenning van veiligheidsrisico's. Over het algemeen zijn medewerkers, nadat veiligheidsrisico's zijn onderkend, wel intrinsiek gemotiveerd om te interveniëren. Daarnaast blijkt het tijdig nemen van herstelmaatregelen echter een zwakke schakel in het risicoreductieproces te zijn; uit de data-analyse blijkt dat dergelijke maatregelen vaak niet of niet tijdig worden geïmplementeerd.

Uit de data-analyse blijkt dat respondenten werkzaam in de procesindustrie relatief minder moed om te interveniëren tonen, maar als en wanneer veiligheidsrisico's voor hen duidelijk zijn, nemen zij wel tijdig maatregelen. In deze sector zijn herstelmaatregelen blijkbaar onderdeel van een logische risicobenadering en is moed blijkbaar geen voorwaarde om te interveniëren. De respondenten, werkzaam in de olie- en gasindustrie, hebben in vergelijking met andere sectoren de risicoreductiefasen Herkenning van risico's (Recognition) en tijdige herstelmaatregelen (Action) het hoogst gewaardeerd. Dit geeft aan dat de respondenten in deze sector bijzonder alert zijn op veiligheidsrisico's. Mogelijk speelt hier een rol dat in deze sector sprake is van zeer hoge veiligheidsrisico's en dat de respondenten, werkzaam op afgelegen locaties, zonder eenvoudige vluchtmogelijkheid, altijd zelf het slachtoffer zijn van ernstige incidenten. In de sector algemene infrastructuur melden de respondenten dat veiligheidsrisico's goed worden onderkend en dat tijdig herstelmaatregelen worden genomen. In deze sector tonen respondenten op operationeel niveau echter weinig moed om te interveniëren. Analyse van de data die zijn aangeleverd door de bedrijfssectoren die hierboven niet zijn genoemd, leverde geen andere dan gemiddelde resultaten op.

Gespecificeerd naar hiërarchische positie, ontdekten wij dat respondenten op hogere hiërarchische posities relatief hoog scores toekennen. Dit geeft aan dat leidinggevenden een gunstiger beeld hebben van de risicoreductiecapaciteit in hun organisatie dan medewerkers in uitvoerende functies. De ondersteunende staf (in deze groep bevinden zich de veiligheids- en kwaliteitsadviseurs) is duidelijk de meest kritische groep waar het de risicoreductiecapaciteit van hun organisaties betreft. Deze groep kende de laagste scores van alle hiërarchische niveaus toe.

Tegenstrijdigheden

Tijdens de primaire analyse van de onderzoeksresultaten ontdekten wij in de uitkomsten daarvan twee verschillende tegenstrijdigheden.

De eerste tegenstrijdigheid betreft de uitkomsten van de statistische analyses van de resultaten van de online prospectieve enquête. Deze suggereerden n.l. dat een taak-georiënteerde leider als een 'veilige' leider moet worden beschouwd. Tijdens hun reflecties op de onderzoeksresultaten reageerden veel van de door ons gesproken leiders enigszins verbaasd op dit analyseresultaat. In hun perceptie is een 'ideale leider' n.l. een leider die kenmerken vertoont als persoonlijke betrokkenheid, wederzijds respect, empowerment, en die psychologische veiligheid biedt. In onze onderzoeksopzet werden taakgeoriënteerde leiders echter beschouwd als presteerders (z.g. 'achievers'), die zich met name richten op het behalen van productiedoelstellingen en weinig ophebben met de veiligheidsaspecten van het primaire proces. Daar bevond zich dus een tegenstrijdigheid.

Met betrekking tot deze tegenstrijdigheid is het ook interessant om te verwijzen naar de opvattingen van de 18 professionele incidentenonderzoekers, die betoogden dat taakgerichte leiders juist niet als een veilig type leiders worden beschouwd; de onderzoekers noemde dit type leider zelfs als meest instrumenteel voor het veroorzaken van ernstige incidenten. Op basis van de tegenstrijdigheid tussen de uitkomsten van de prospectieve enquête, de reflecties van leiders en de retrospectieve analyses door incidentenonderzoekers, besloten wij onze primaire analyse nader te beschouwen.

Ten aanzien van deze geïdentificeerde tegenstrijdigheid, achtten wij een fout in de indeling van de onderzoeks-indicatoren in de drie leiderschapsoriëntaties mogelijk. Indachtig het enkele/dubbele lus-concept (single/double loop learning) besloten wij het bewijs voor een (on-)juistheid bij de bron, dus in de a-priori indeling van de leiderschapsoriëntaties (taak, relatie en dominantie) te zoeken. Daartoe hebben wij een Exploratory Factor Analysis (EFA) en daarna (op een andere populatie) een Confirmatory Factor Analysis (CFA) uitgevoerd. Beide analyses toonden onomstotelijk aan dat de a priori vastgestelde taak-leiderschapsoriëntatie in feite uit twee *verschillende* oriëntaties bestaat.

Naar aanleiding van deze analyseresultaten hebben wij de indeling van de leiderschapsoriëntaties opnieuw gedefinieerd en de taak-oriëntatie opgesplitst in twee nieuwe leiderschapsoriëntaties: proces-oriëntatie en productie-oriëntatie. Door deze ontwikkeling ontstonden er vier (relatie, proces, productie en dominantie) in plaats van drie leiderschapsoriëntaties. Op basis van dit resultaat hebben wij het veiligheidsleiderschapsmodel aangepast.

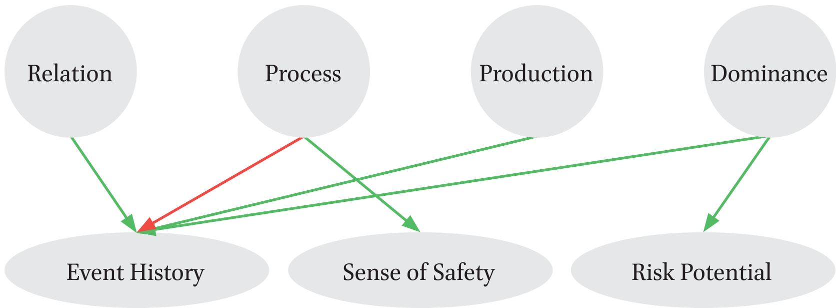
De tweede tegenstrijdigheid troffen we aan in de analyseresultaten van de eerste risicoreductiefase van de risicoreductiecyclus: 'Herkennen van risico's'. De uitkomsten van de statistische analyses van de enquêteresultaten laten zien dat 'Herkenning van risico's' door veel respondenten als de best of de op één na best scorende risicoreductiefase wordt beschouwd. Dit patroon gold voor alle hiërarchische niveaus (leiders en volgers). In hun reflecties op deze uitkomsten verklaarden verschillende senior leiders echter dat een aantal van de hoge waarderingen voor 'Herkenning' (vooral door leidinggevende respondenten) niet de realiteit op operationeel niveau vertegenwoordigen. Uit de retrospectieve analyse van casuïstiek door incidentonderzoekers bleek zelfs dat de 'Herkenning van risico's' als de meest gecompromitteerde risicoreductiefase moet worden beschouwd en dat men dit dus juist laag zou moeten scoren. Deze verklaring werd bevestigd door de vijf professionele risicoanalysedeskundigen, die suggereerden dat het niet herkennen van veiligheidsrisico's, onbegrip, of het negeren van bekende risico's, in hoge mate bijdraagt aan het optreden van ernstige incidenten. Bovendien worden de opvattingen van de incidentenonderzoekers en risicoanalysedeskundigen ondersteund door de analyses van de Onderzoeksraad voor Veiligheid, die in verschillende onderzoeksrapporten het gebrek aan herkenning en erkenning van veiligheidsrisico's noemt als een belangrijke factor voor het ontstaan van ernstige incidenten.

Ook deze tegenstrijdigheid hebben wij nader onderzocht. Daarbij is ons gebleken dat er sprake is van verklaarbare verschillende opvattingen van interne respondenten en externe risicomanagementexperts. Daardoor zijn wij tot de conclusie gekomen dat de hier gevonden tegenstrijdige resultaten voortkomen uit de verschillen in optiek tussen de respondenten en de risicomanagementexperts, die hun oorsprong vinden in de verschillende organisatorische posities, rollen en operationele ervaring. Daarbij zijn wij door alle personen oprecht, maar verschillend geïnformeerd. Het ontkennen van deze tegenstrijdigheid zou de waarheid geweld aandoen en dus bestond hier geen aanleiding voor het doen van aanpassingen.

Invloed van leiders op veiligheid

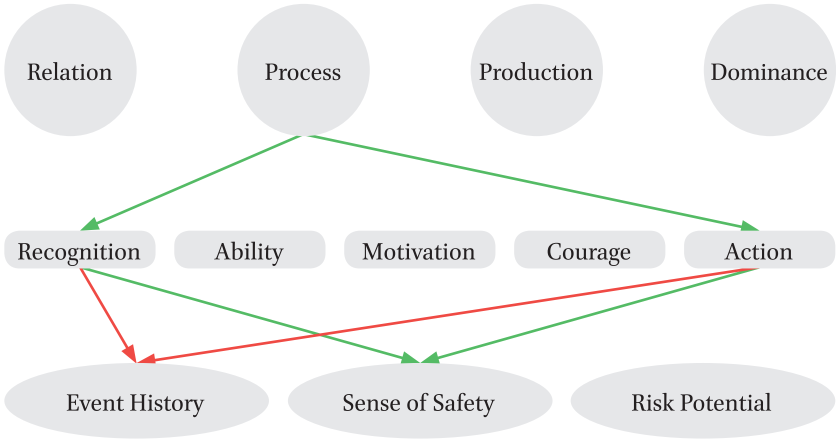
Om de invloed van leiders op het voorkomen van veiligheidsincidenten te bepalen, hebben wij een oorzakelijk- pad-analyse (Structural Equation Modelling) toegepast. De uitkomsten van deze pad-analyse geven aan dat leiders veiligheid op twee verschillende wijzen beïnvloeden: a. door de *directe* invloed van de leiderschapsoriëntaties op de veiligheidskenmerken (Fig.3) en b. door een door het risicoreductieproces gemedieerde, *indirecte* invloed op de veiligheidskenmerken (Fig.4).

In onderstaande figuren worden deze twee verschillende invloeden gevisualiseerd. In deze figuren indiceren groene pijlen positieve en rode pijlen negatieve invloed van de verschillende leiderschapsoriëntaties op de veiligheidskenmerken. In de pad-analyse gevonden niet-significante relaties worden in deze figuren niet getoond.



FIGUUR 3 Directe invloed van leiderschapsoriëntaties op veiligheid

Figuur 3 toont de *directe* invloed van verschillend georiënteerde leiders op de veiligheidskenmerken. In deze figuur zien wij groene pijlen van relatie-, productie-, en dominante-oriëntaties naar het aantal veiligheidsincidenten (Event History). Dit betekent dat in dit onderzoek positieve relaties zijn gevonden tussen deze drie leiderschapsoriëntaties en het aantal veiligheidsincidenten. Ten aanzien van proces-georiënteerde leiders is ten aanzien van het aantal veiligheidsincidenten juist een negatieve relatie (rode pijl) gevonden. Deze bevindingen suggereren dat onder leiding van relatie-, productie-, en dominante-georiënteerde leiders het ontstaan van veiligheidsincidenten waarschijnlijker is dan onder leiding van proces-georiënteerde leiders. Tevens toont deze figuur een positieve relatie (groene pijl) tussen de dominante-oriëntatie en risicopotentieel (Risk Potential). Dit suggereert dat medewerkers die onder dominant georiënteerde leiders werken, meer potentiële risico's zien dan medewerkers die onder anders georiënteerde leiders werken. Als enige leiderschapsoriëntatie toont proces-oriëntatie een groene pijl naar de veiligheidsbeleving van medewerkers (Sense of Safety). Deze geeft aan dat medewerkers die onder proces-georiënteerde leiders werken een positieve veiligheidsbeleving hebben.



FIGUUR 4 Indirecte (gemedieerde) invloed van leiderschapsoriëntaties op veiligheid

Figuur 4 toont de door het risicoreductieproces gemedieerde, *indirecte* invloed van de verschillend georiënteerde leiders op de veiligheidskenmerken. In deze figuur zien wij geen pijlen vanuit relatie-, productie- en dominante-oriëntaties; dit betekent dat dergelijk georiënteerde leiders geen vermeldingswaardige indirecte invloed op veiligheid hebben. Ook worden er geen pijlen getoond van en naar de risicoreductiefasen Kunnen (Ability), Motivatie (Motivation) en Moed (Courage). Dit betekent dat deze risicoreductiefasen in de relatie tussen leiders en veiligheid geen vermeldingswaardige bijdrage leveren. Ook is bij deze analyse geen relatie met het risicopotentieel (Risk Potential) gevonden.

De enige vermeldingswaardige invloed gaat uit van proces-georiënteerde leiders. Deze leiders tonen positieve relaties (groene pijlen) met de risicoreductiefasen Recognition (Kennen van risico's) en Action (Tijdige herstelmaatregelen). Vervolgens tonen deze twee risicoreductiefasen beide een positieve relatie (groene pijlen) met de veiligheidsbeleving van medewerkers (Sense of Safety) en een negatieve relatie (rode pijlen) met het aantal veiligheidsincidenten (Event History).

Samenvattend suggereren de uitkomsten van de pad-analyse dat de invloed van leiders op veiligheid in hoge mate afhangt van hun specifieke leiderschapsoriëntatie. Zowel de uitkomsten van de analyse van de *directe* invloed van leiders op veiligheid, als de uitkomsten van de analyse van de, door het risicoreductieproces gemedieerde, *indirecte* invloed, geven aan dat proces-georiënteerde leiders als enige a. positieve invloed hebben op de beleving van veiligheid (Sense of Safety) en b. negatieve invloed heeft op het ontstaan van veiligheidsincidenten (Event History). Tevens suggereren de uitkomsten van de analyse van de *directe* relatie tussen leiderschapsoriëntaties en veiligheid, dat relatie-, productie- en dominante-georiënteerde leiders allen een negatieve invloed op veiligheid hebben.

Conclusies

Risicoreductie

Met betrekking tot risicoreductie hebben wij laten zien dat medewerkers, en vooral leiders, te optimistisch zijn over de kwaliteit van risicoherkenning. Ook is duidelijk geworden dat herstelmaatregelen naar aanleiding van geïdentificeerde veiligheidsrisico's een lage prioriteit hebben. Ook voor dat laatste geldt dat leiders hierover een positievere perceptie hebben dan medewerkers.

Invloed van leiders op veiligheid

Met betrekking tot de invloed van leiders op veiligheid concluderen wij dat proces-georiënteerde leiders als 'meest veilige' leiders kunnen worden beschouwd, dat onder productie- en relatie-georiënteerde leiders de kans op veiligheidsincidenten groter is en dat dominantie-georiënteerde leiders een 'veiligheids-aversieve' groep vertegenwoordigen.

Op basis van de in de pad-analyse gevonden verschillen in intensiteit tussen gemedieerde en niet-gemedieerde invloed van leiders op veiligheid, concluderen wij dat goede persoonlijke relaties tussen leiders en volgers relatief sterke indicatoren zijn voor de effectiviteit van Safety Leadership.

Op basis van de totale onderzoeksresultaten concluderen wij dat procesgeoriënteerde leiders, die hun volgers motiveren om te interveniëren wanneer veiligheidsrisico's zich voordoen, mensen vergeven wanneer ze dit onnodig (per ongeluk) doen, ervoor zorgen dat tijdig de noodzakelijke verbeteringen worden aangebracht en die op geloofwaardige wijze de boodschap overbrengen dat operationele veiligheid prioriteit verdient, de beste kandidaten zijn om succesvol veiligheidsincidenten te voorkomen.

> Als antwoord op de centrale onderzoeksvraag concluderen wij het volgende: "Leiders hebben inderdaad invloed op het voorkomen van veiligheidsincidenten en organisaties zijn het beste gediend met procesgeoriënteerde leiders, die zich richten op het herkennen van risico's en zorgen voor tijdige implementatie van risicoreducerende maatregelen".

Aanbevelingen

Op basis van de bovenstaande conclusies hebben wij de navolgende 'Procesgerichte Veiligheidsleiderschaps-principes' ontwikkeld: 1. Beknibbel niet op veiligheid; 2. Zorg voor voldoende bekwaam personeel; 3. Stel alle medewerkers in staat hun taak op een veilige manier uit te voeren; 4. Stimuleer medewerkers om werk onder onveilige omstandigheden te weigeren; 5. Organiseer professionele veiligheidsleiderschapstrainingen voor alle leiders op alle niveaus; 6. Neem voldoende tijd voor dialoog met het personeel op hun werkplek; 7. Moedig identificatie en communicatie van veiligheidsrisico's actief aan; 8. Monitor implementatie en de behaalde effecten van risicoreducerende maatregelen.

We adviseren leiders op alle niveaus van de organisatie (leden van de raad van commissarissen, leden van de raad van bestuur, CEOs, directeuren, managers en operationele toezichthouders) om deze principes volledig te omarmen en te implementeren in hun organisaties. Daarbij raden wij leiders aan deze aanbevelingen te interpreteren in de context van hun verschillende individuele posities, rollen en verantwoordelijkheden. Wij stellen ook voor deze principes op te nemen als onderdeel van het corporate governance-beleid en op te nemen in corporate governance-verklaringen van organisaties.

Daarnaast achten wij het belangrijk dat regelgevende instanties, waaronder overheidsinspecties en certificatie-instellingen, evenals veiligheidsopleidingsinstellingen, deze Procesgerichte Veiligheidsleiderschaps-principes' opnemen in hun toezichthoudende en educatieve strategieën.

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15 Appendices

15.1 Qualification info of incident investigators

Retrospective review of safety crises				Info concerning reviewers	
I.D. code	Years in safety	Years incident investigator	Number of incident investigations	Sectors of investigations	Tools
1	11	11	30+	Hospitals, health care	Tripod Beta
2	17	17	30+	All Sectors	Timeline, Tripod Beta, STEP, STAMP, HFACS, Prisma, Accimap
3	26	26	30+	Oil&Gas, hospitals, process industry, general infra	Tripod Beta
4	30	25	30+	Tank storage, process industry	Tripod Beta, RCA, many others
5	16	16	30+	All sectors	Tripod Beta, RCA, TopSet, Taproot, SIM, BSCAT, Sologic, 5W
6	18	17	30+	All, except hospitals	Tripod Beta, RCA, TopSet, SIM, BSCAT, Prisma, Sologic, 5W
7	24	22	30+	Rail and general infra	Tripod Beta, Prisma, HRA, Cascade-model, FAM, 5W
8	31	28	30+	Rail	SOAT, FAT, Tripod Beta, Bowtie
9	6	7	30+	All sectors	Local Rationality, FRAM, Tripod Beta, SIM, STAMP, Multi Actor Timeline
10	12	12	30+	All sectors	Tripod Beta, RCA
11	20	20	30+	All sectors	Tripod Beta, RCA, BSCAT, 5W
12	10	10	30+	All sectors	Tripod Beta, SIM, RCA
13	31	31	30+	Oil&Gas, tank storage, process industry	Tripod Beta, FMEA, Deep Learning, TopSet, 5W
14	12	12	30+	All, except hospitals	Tripod Beta, TRACK, TopSet, SIM
15	14	8	30+	Oil&Gas	MSCAT, TopSet, Tripod Beta, Casual Learning
16	13	10	30+	Genral infra, rail	Tripod Beta, 5W, SOAT
17	14	10	>10<20	Rail	Tripod Beta
18	16	10	30+	All sectors	Tripod Beta, TopSet, FRAM, BSCAT, SIM, GBV

TABLE 20 Qualifications of incident investigators

15.2 Guideline for incident investigators

Expert research into the role of leaders in incidents

Objective of this sub-study

This sub-study is part of a research into the role of leaders in the occurrence of safety incidents. This sub-study looks for the way in which leaders (possibly in the background) have influenced the occurrence of security incidents.

Introduction

In my research I use two concepts: A Risk Reduction Process and Safety Leadership orientations.

In order to be able to conduct the review of existing incident analyses in a structured way, some understanding of these two concepts is required. In the section 'References' (on the next page) I explain these terms. If you think more explanation is needed, I will be happy to provide that.

My request

My request to you is to consider in more detail the role and behaviour of leaders who directly or indirectly influenced the origin of an incident you have investigated.

I have sent an example commentary for this purpose.

I am making this request to 15 experts/incident investigators. In order to be able to meaningfully analyse all reviews, as much uniformity as possible in the data is required. To this end I have also sent a template. In it you can post your commentary on the incident you selected. This makes it a fill-in-the-blank exercise, which also saves you time. In a pilot, conducted among three colleagues, it appeared that this fill-in exercise takes about an hour. I am very grateful to you for taking that time for me.

Criteria

You write your comment independently; I am not allowed to get involved in personal bias.

Select an incident with at least the following (potential) consequence: death or permanent disability, or major economic/production loss, or serious environmental or reputation damage.

This incident must have really happened and must have happened in the Netherlands after 2000.

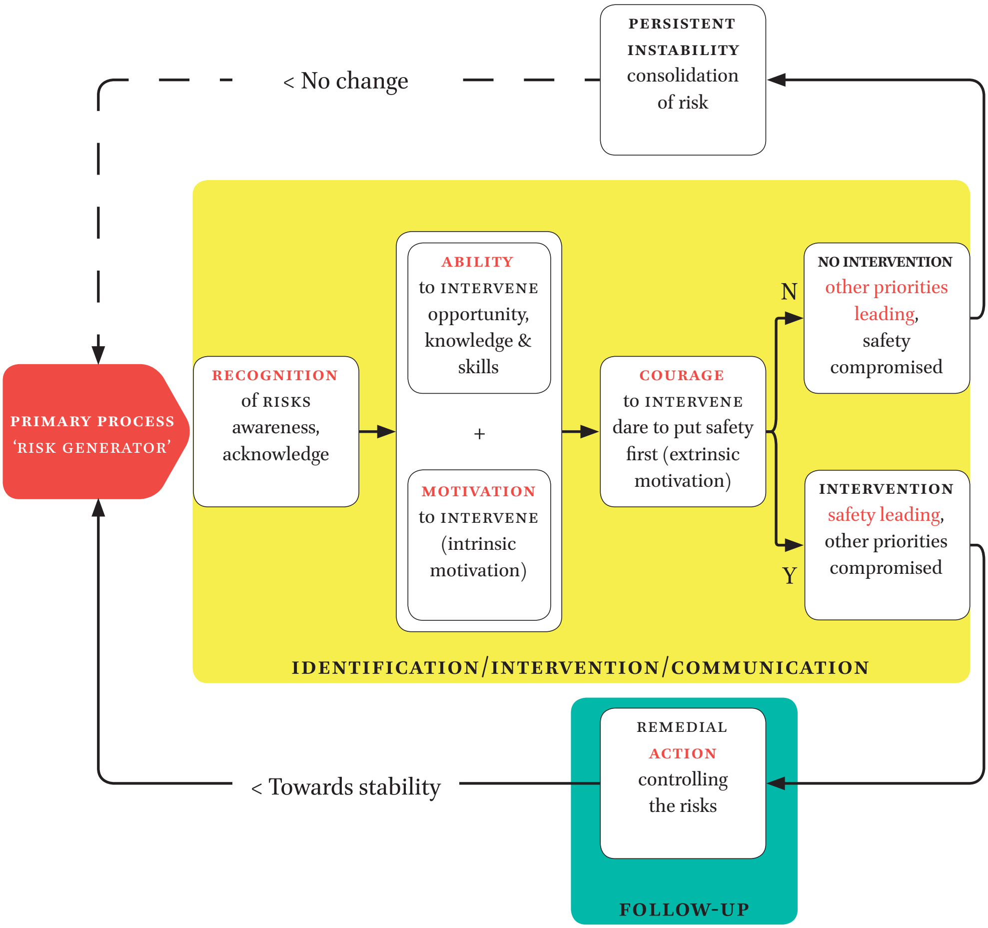
All information must be anonymised, so that the commentary cannot be traced back to people by outsiders.

As a guideline: The scenario of the incident does not have to be more than 1 A4 (half an A4 is even better).

References

The Risk Reduction Process

'Management of safety' means 'reducing risks.' The risk reduction process consists of 5 critical phases: Knowledge, Ability, Motivation, Courage and Doing. To illustrate that process, I use the model below.



If all 5 risk reduction phases are effective, the risks are optimally reduced.

– People recognize the risks (Recognition);
– People are able to intervene (Ability);
– People are motivated to intervene (Motivation);
– People dare to intervene by, for example, interrupting production (Courage);
– Risk-reducing measures are taken in time (Action).

If one or more risk reduction phase (s) does not function optimally, the following situations may arise:

– People do not recognize the risks;
– People are unable to intervene;
– They do not want to intervene;
– People do not dare to intervene;
– Measures are not taken on time.

If that is the case, the basis for incidents has been laid.

Safety Leadership orientations

Leaders (supervisors, managers, etc.) can, on the basis of their role/function in an organisation, have a positive or negative influence on the effectiveness of the above risk reduction phases.

People, including leaders, have personal preferences when it comes to their behaviour. We call these 'orientations.' In this research I limit myself to the following three orientations:
1. Task (The leader mainly focuses on completing the work);
2. Relation (The leader mainly focuses on stimulating good mutual relationships);
3. Self (The leader is mainly self-centred; he thinks highly of himself).

Everyone has something (or more) of all three orientations. The degree to which these orientations are present in us affects how we behave.

In my research I try to determine to what extent the behaviour of leaders has a negative influence on the effectiveness of the risk reduction process. In other words: To what extent does the behaviour of leaders determine the risk of incidents?

Incident review template

Description of the incident

A. Scenario (What happened?)

…… (your text here)

B. What was the (potential) effect (damage/injury)?

…… (your text here)

C. What was the situational context of this incident?

…… (your text here)

D. What underlying causes were there?

…… (your text here)

Matrix for influence of leaders on the risk reduction process

Safety is risk reduction. Disruption of the risk reduction process increases the risk of incidents.

A. Which leaders negatively impacted the risk reduction process that triggered the incident?
B. Indicate for these leaders to what extent they had a negative influence on the effectiveness of the risk reduction phases (Know, Can, Want, Dare, Do).

Explanation: Several choices are possible for each person in terms of risk reduction phase AND degree of influence.

Possible scores per phase: 0 (no negative influence), 1 (very little), 2 (little), 3 (quite), 4 (much), 5 (very much)

N.B. A high score (e.g., 5) therefore means that that person had a very significant negative influence on the effectiveness of the specific risk reduction phase, which increased the chance of incidents. A low score (e.g., 1) means that that person had very little negative impact on that particular phase.

(The grey rows are examples)

Which leader? ↓	RECOGNITION **Recognition and understanding**	ABILITY **Knowledge, skills, and opportunities to intervene**	MOTIVATION **Internal motivation to intervene**	COURAGE **Courageous enough to intervene(e.g. by interrupting production)**	ACTION **Implementation of risk reducing measures**
Leader A. (position)	5				3
Leader B. (position)		3		1	5
1. …					
2. …					
3. …					
4. …					
5. …					

Matrix for personal orientations in the behaviour of the leader(s)

Indicate how the leaders, you mentioned in 2, generally behave:

- Task (The leader is focused on completing the work);
- Relation (The leader is aimed at stimulating good mutual relationships);
- Self (The leader is self-centred; he thinks highly of himself).

Explanation: Every person has some of all three orientations (Task, Relation, Self); this is about the degree to which the leaders show the different orientations in their behaviour.

Possible scores per leader: 0 (none), 1 (very little), 2 (little), 3 (quite), 4 (a great deal), 5 (very much)

(Grey lines are examples)

	TASK-oriented	RELATION-oriented	SELF-oriented
Leader A. (position)	3	1	2
Leader B. (position)	1	3	2
1.			
2.			
3. ...			
4. ...			
5. ...			

15.3 Survey questionnaire used in pilot survey

This questionnaire is processed anonymously and we cannot link the information you provide to your person.
Do you give permission to use the information you provide anonymously for scientific research?

- O Yes
- O No — In case this is the answer, the session is aborted.

1 **To what extent do the following situations contribute to the occurrence of accidents?**

	(Almost) never	Sometimes	Often	(Almost) always	Don't know
The risks are not known/seen in the workplace	O	O	O	O	O
People are unable to solve the risks in the workplace	O	O	O	O	O
There is a lack of motivation in the workplace to intervene	O	O	O	O	O
The risks are known, but nobody dares to intervene	O	O	O	O	O
Known risks are not always resolved or are resolved much too late	O	O	O	O	O

2 **Who are in the best position to resolve these situations?**

	Board of directors	Management	Local supervision*	Operational staff	Don't know
The risks are not known/seen in the workplace	O	O	O	O	O
People are unable to solve the risks in the workplace	O	O	O	O	O
There is a lack of motivation in the workplace to intervene	O	O	O	O	O
The risks are known, but nobody dares to intervene	O	O	O	O	O
Known risks are not always resolved or are resolved much too late	O	O	O	O	O

* examples of local leadership are: team leader/foreman/workshop foreman/guard chief/trade manager/etc.

3 **Your direct supervisor is:**

- O The director
- O A manager
- O a local leader: e.g., team leader/foreman/workshop foreman/guard chief/trade manager/etc.

4 **Your direct supervisor is:**

- O Man
- O Woman

5 **Consider the manager from the previous question and make your assessment below about his/her behavior**

	(Almost) never	Sometimes	Often	(Almost) always
Listens well	O	O	O	O
Supports and encourages	O	O	O	O
Ensures (maintenance of) a good atmosphere	O	O	O	O
Let employees participate in the discussion and decision-making	O	O	O	O
Encourages active participation from all team members	O	O	O	O
Sometimes comes across as hostile	O	O	O	O
Avoids involvement	O	O	O	O
Is predominant	O	O	O	O
Abusing the good will of others	O	O	O	O
Makes good appearance with the work of others	O	O	O	O
Comes up with ideas and stimulates renewal/innovation	O	O	O	O
Is interested in ideas of employees and deals with them positively	O	O	O	O
Ensures that employees can perform their duties properly	O	O	O	O
Ensures that employees receive the correct information in a timely manner	O	O	O	O
Encourages employees to take joint decisions where possible	O	O	O	O
Is enthusiastic, can get people moving	O	O	O	O
Is honest and sincere	O	O	O	O
Is attentive and gives compliments where appropriate	O	O	O	O
Attaches to status, considers his/her own position in the organization important	O	O	O	O
Trying to give employees what they need	O	O	O	O
Is compassionate, helps where possible	O	O	O	O
Shows understanding if someone, out of prudence, has unnecessarily disrupted production	O	O	O	O
Sometimes overlooks something; is flexible with rules and procedures	O	O	O	O
Radiates confidence	O	O	O	O
Dares to make decisions based on his/her intuition	O	O	O	O
Is individualistic, goes his/her own way	O	O	O	O
has guts; does what he/she deems right, even if procedures prescribe otherwise	O	O	O	O
is patient	O	O	O	O
Is knowledgeable and understands what his/her employees are doing	O	O	O	O
Dares to make decisions	O	O	O	O
Is result-oriented; everything has to give way to meeting deadlines	O	O	O	O
Motivates employees to intervene themselves in case of safety risks	O	O	O	O
Stimulates knowledge development among employees	O	O	O	O
Ensures that necessary improvement measures are implemented	O	O	O	O
Does not compromise on safety; 'safety first!'	O	O	O	O

6 **How long have you been working in this industry?**

- O Less than 5 years
- O 5-10 years
- O 10-15 years
- O Over 15 years

9 **How long have you been working in your current position?**

- O Less than 5 years
- O 5-10 years
- O 10-15 years
- O Over 15 years

7 Your position:
Select one of the following options:

- O Operational staff
- O Local supervisor
- O Support staff
- O Manager
- O Director

10. You are a:

- O Man
- O Woman

8 Have you ever experienced a serious accident at close quarters, at work or outside it?

- O Yes
- O No

11 Your age:

- O Younger than 25
- O 25-35
- O 35-45
- O 45- 55
- O Over 55

15.4 Correlational effect size benchmarks (Bosco et al.)

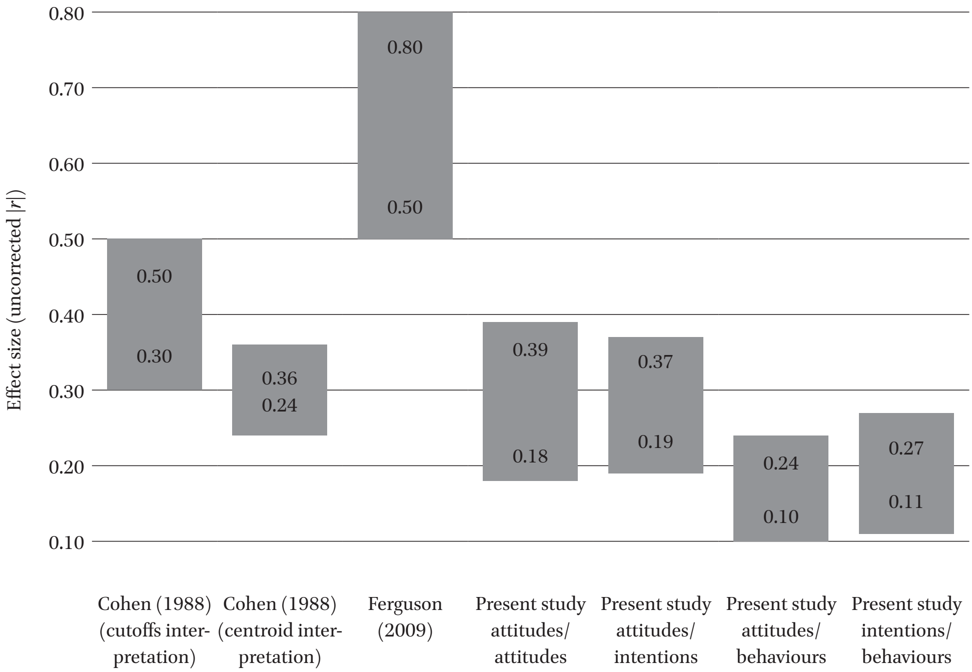


TABLE 21 Correlational effect size benchmarks

15.5 Online prospective survey questionnaire

Welcome to this study of the relationship between leadership and security.

By answering the questions below, you make an important contribution to this research.

Your answers are processed ANONYMOUSLY, so no one can see who gave which answers. It takes about 8 minutes to answer the questions.

We thank you in advance for your participation.

NOTE: This survey is also part of a research at Leiden University.

Do you give permission to use the results of this survey for scientific research?

1 YES, I give permission to use my answers anonymously for scientific research.
2 NO, I do not consent to my answers being used for scientific research. (This choice will automatically end the survey.)

Q3 Thank you for your willingness to participate in this study!
Click on 'Next' for the first questions.

Q4 In which sector do you work?

☐ Tank storage
☐ Hospitals
☐ Railway sector
☐ Mineral extraction (Oil and gas, salt)
☐ Process industry/chemistry
☐ Transport
☐ Maintenance/maintenance
☐ Construction industry
☐ Industry in general
☐ Other, namely .... (Please fill in your sector below.)__________________

Q5 What is your age?

Q6 How many years have you been working in this industry/sector? (if less than 1 year, please enter 0)

Q7 What is your current position in this organisation?

☐ Executive/production employee
☐ Manager (team leader/foreman/chief/head/supervisor/supervisor/specialist/etc.)
☐ Advisory staff member
☐ Manager
☐ Director

Q8 How many years have you worked in your current position? (if less than 1 year, please enter 0)

Q9 Have you ever experienced a serious accident up close, at work or elsewhere? (Note: the term 'serious' is not further defined here: If you considered an accident to be 'serious', this is sufficient reason to answer this question with YES.)

☐ YES, as a victim
☐ YES, indirectly (e.g., as a witness, helper, friend, family, etc.)
☐ NO

Q10 Have you ever interrupted or delayed production for safety reasons?

☐ Yes, I have interrupted production once
☐ Yes, I have slowed down production sometimes
☐ No, I have never done this

Q11 A few situations are described below. Indicate whether these situations are actually the case for you:

	Strongly disagree	**Disagree**	**Slightly disagree**	**Neutral**	**Slightly agree**	**Agree**	**Strongly disagree**	**Don't Know**
In the workplace, people are aware of the local safety risks	○	○	○	○	○	○	○	○
In the workplace, people are able to solve those safety risks	○	○	○	○	○	○	○	○
In the workplace, people are motivated to solve safety risks	○	○	○	○	○	○	○	○
On the work floor, people dare to intervene themselves to solve safety risks	○	○	○	○	○	○	○	○
Known safety risks are resolved in a timely manner	○	○	○	○	○	○	○	○

Q12 A few situations are described below. Indicate for each situation who do you think can best solve that situation? (several people possible)

	Board	Management	Supervisors	Operational staff	Don't know
In the workplace people are insufficiently aware / aware of the safety risks	○	○	○	○	○
People in the workplace are insufficiently able to solve safety risks	○	○	○	○	○
People in the workplace are insufficiently motivated to solve safety risks	○	○	○	○	○
The safety risks are known, but people do not dare to intervene themselves in the workplace	○	○	○	○	○
Known safety risks are not resolved or are resolved too late.	○	○	○	○	○

Q13 Your immediate supervisor is:

- ☐ The director
- ☐ A manager
- ☐ A supervisor (team leader/foreman/chief/head/supervisor/supervisor/manager/etc.)
- ☐ I do not have a supervisor

Q14 Your immediate supervisor is:
- ☐ Man
- ☐ Woman

Q15 Take your immediate supervisor (from the previous question) in mind and give an impression of his/her behaviour below.
Your immediate supervisor...

	Strongly disagree	**Disagree**	**Slightly disagree**	**Neutral**	**Slightly agree**	**Agree**	**Strongly disagree**	**Don't Know**
... is a good listener	○	○	○	○	○	○	○	○
... supports and encourages	○	○	○	○	○	○	○	○
... ensures (maintenance of) a good atmosphere	○	○	○	○	○	○	○	○
... let employees participate in the discussion and decision- making process	○	○	○	○	○	○	○	○
... encourages active participation of all team members	○	○	○	○	○	○	○	○
... sometimes comes across as hostile	○	○	○	○	○	○	○	○
... avoids involvement	○	○	○	○	○	○	○	○
... is predominant	○	○	○	○	○	○	○	○
... takes advantage of the goodwill of others	○	○	○	○	○	○	○	○
... makes a good impression with the work of others	○	○	○	○	○	○	○	○
... comes up with ideas and stimulates renewal and innovation	○	○	○	○	○	○	○	○
... is interested in ideas from employees and deals with them positively	○	○	○	○	○	○	○	○

Q16 Your immediate supervisor…

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly disagree	Don't Know
… ensures that employees can perform their tasks properly	○	○	○	○	○	○	○	○
.. arranges that employees receive information on time	○	○	○	○	○	○	○	○
… encourages employees to make joint decisions where possible	○	○	○	○	○	○	○	○
… is enthusiastic and can get people moving	○	○	○	○	○	○	○	○
… is honest and sincere	○	○	○	○	○	○	○	○
… is considerate and gives compliments where appropriate	○	○	○	○	○	○	○	○
… values status, considers his / her organisational position important	○	○	○	○	○	○	○	○
… tries to give employees what they need	○	○	○	○	○	○	○	○
… is compassionate, helps where possible	○	○	○	○	○	○	○	○
… shows understanding when, out of caution, someone has unnecessarily disrupted production	○	○	○	○	○	○	○	○
… sometimes overlooks something; handles rules and procedures flexibly	○	○	○	○	○	○	○	○
… radiates confidence	○	○	○	○	○	○	○	○

Q17 Your immediate supervisor...

	Strongly disagree	**Disagree**	**Slightly disagree**	**Neutral**	**Slightly agree**	**Agree**	**Strongly disagree**	**Don't Know**
... dares to make decisions based on intuition	○	○	○	○	○	○	○	○
... is individualistic, goes his/her own way	○	○	○	○	○	○	○	○
... has guts, does what he / she considers right, even when procedures prescribe otherwise	○	○	○	○	○	○	○	○
...is patient	○	○	○	○	○	○	○	○
... is knowledgeable, understands what employees are doing	○	○	○	○	○	○	○	○
... dares to make decisions	○	○	○	○	○	○	○	○
... is result oriented; everything has to make way for meeting deadlines	○	○	○	○	○	○	○	○
... motivates employees to intervene in case of safety risks	○	○	○	○	○	○	○	○
... stimulates knowledge development among employees	○	○	○	○	○	○	○	○
... ensures that necessary improvements are made	○	○	○	○	○	○	○	○
... gives safety priority: 'Safety First!'	○	○	○	○	○	○	○	○

Q18 Disruptions in the primary/production process of your I can in the worst-case lead to:

☐ an accident with several fatalities, serious material or environmental damage and reputation damage.
☐ an accident with a fatal outcome or serious material or environmental damage.
☐ an accident resulting in hospitalization.
☐ an accident that leads to an employee's absence.
☐ an accident with minor injury or little material or environmental damage
☐ an incident without injury or material or environmental damage.
☐ I have no idea.

Q19 Have you been taught in any education/training to recognize safety risks?
☐ Yes
☐ No.

Q20 In which training did you learn to recognize safety risks?
☐ Professional training
☐ VCA
☐ Other, namely ___________________

Q21 In which department/business unit/division/etc. do you work?
☐ To be completed later, e.g., Location A, Terminal B, Factory C, Department D
☐ Other, namely ___________________

Q22 To what extent do you agree with the following statements:

	Strongly disagree	**Disagree**	**Slightly disagree**	**Neutral**	**Slightly agree**	**Agree**	**Strongly disagree**	**Don't Know**
I feel safe in my organisation.	○	○	○	○	○	○	○	○
There is a real risk of an accident within my organisation.	○	○	○	○	○	○	○	○
In the field of safety, a great deal has gone wrong within my organisation in the past year.	○	○	○	○	○	○	○	○

15.6 General mean scores

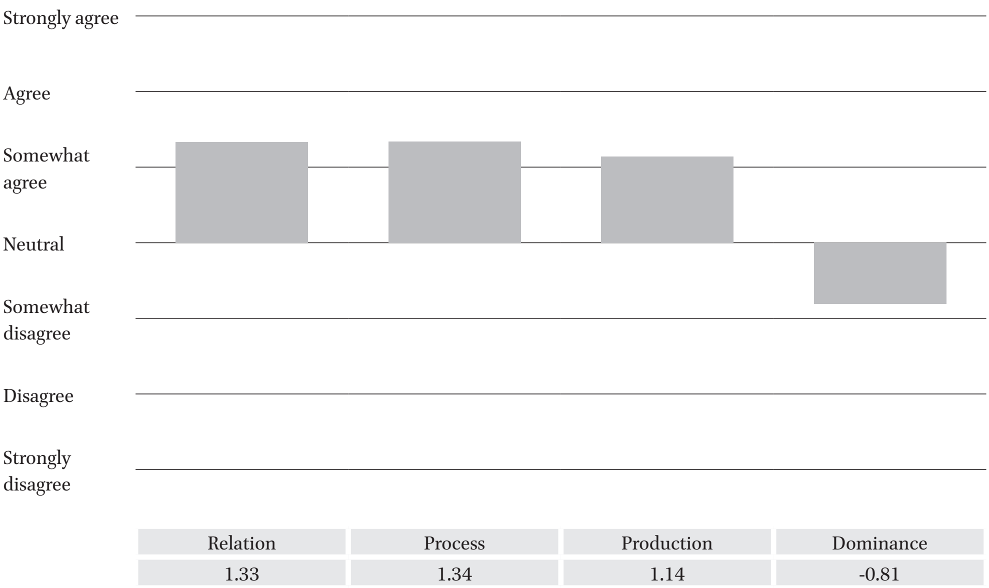
In Chapter 8 we presented the outcomes of the online prospective survey in terms of mean scores. This appendix shows the statistical information underlying the presented outcomes.

15.6.1 *Safety Leadership orientations*

15.6.1.1 General means for Safety Leadership orientations

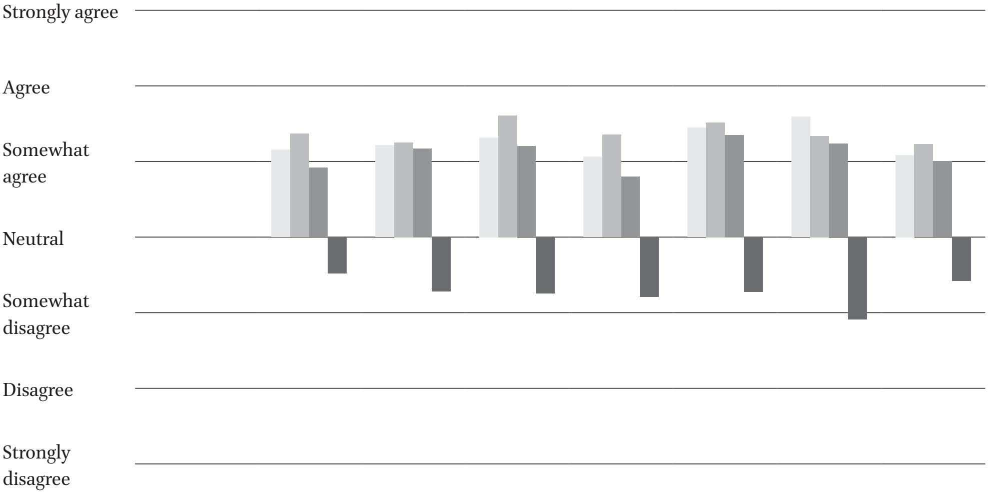
SAFETY LEADERSHIP	Relation	Process	Production	Dominance
Valid	3332	3319	3316	3332
Missing	0	13	16	0
Mean	1.3276	1.3437	1.1370	-0.8121
Std. Deviation	1.19064	1.07288	1.22041	1.13131

TABLE 22 Safety Leadership orientations as reported by general employees



BAR CHART 12 General Safety Leadership profile of all employees

15.6.1.2 Safety Leadership orientations per business sector



		Tank storage (n=185)	Hospitals (n=767)	Process industry (n=128)	Oil & gas (n=414)	Infra general (n=454)	Rail infra (n=1010)	Other (n=374)
	Relation	1.1547	1.2145	1.3169	1.0633	1.4464	1.5910	1.0852
	Process	1.3689	1.2523	1.6087	1.3533	1.5155	1.3360	1.2286
	Production	0.9189	1.1724	1.2031	0.7962	1.3511	1.2350	1.0032
	Dominance	-0.4824	-0.7198	-0.7470	-0.7877	-0.7264	-1.0857	-0.5786

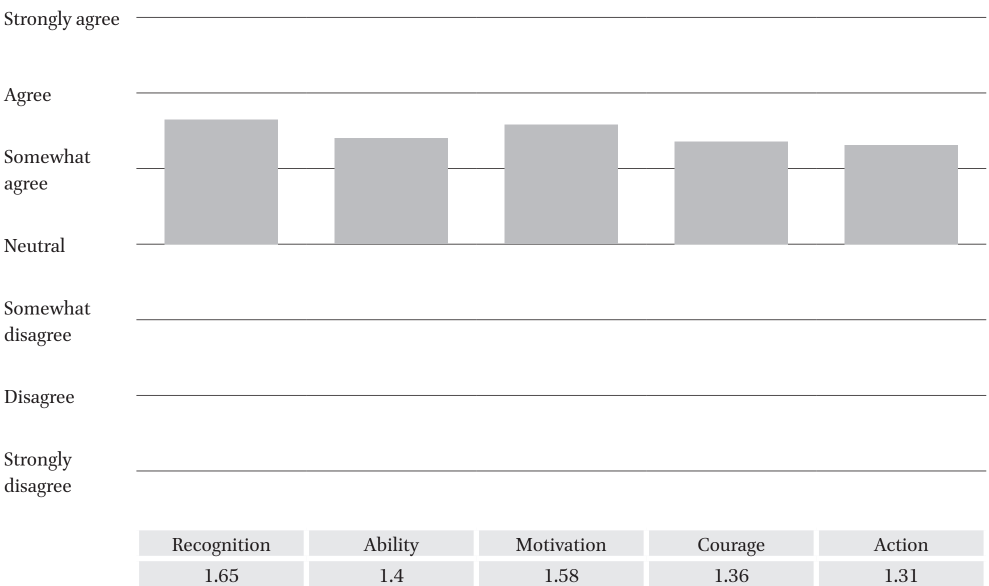
BAR CHART 13 Safety Leadership per business sector

15.6.2 *Risk Reduction Capacity*

15.6.2.1 General means for Risk Reduction Capacity

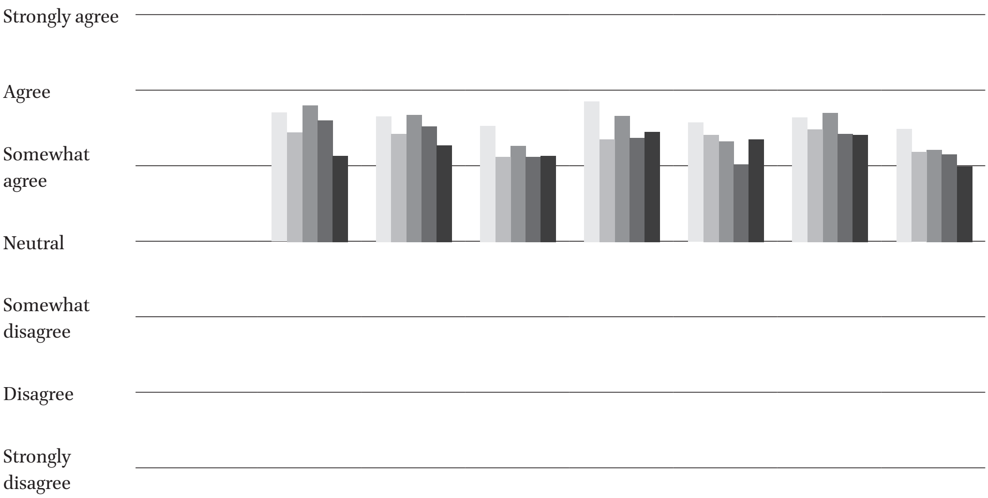
RISK REDUCTION CAPACITY	Recognition	Ability	Motivation	Courage	Action
Valid	3322	3320	3310	3297	3291
Missing	10	12	22	35	41
Mean	1.6508	1.4000	1.5782	1.3588	1.3102
St. Deviation	1.28842	1.27988	1.31422	1.41341	1.45053

TABLE 23 Risk Reduction Capacity as reported by general employees



BAR CHART 14 Risk Reduction Capacity as reported by all employees

15.6.2.2 Risk Reduction Capacity per business sector



	Tank storage (n=185)	Hospitals (n=766)	Process industry (n=127)	Oil & gas (n=414)	Infra general (n=453)	Rail infra (n=1005)	Other (n=373)
Recognition	1.70	1.66	1.54	1.86	1.58	1.65	1.50
Ability	1.45	1.43	1.13	1.36	1.42	1.49	1.19
Motivation	1.81	1.68	1.27	1.67	1.33	1.71	1.22
Courage	1.61	1.53	1.13	1.38	1.03	1.43	1.16
Action	1.14	1.28	1.14	1.46	1.36	1.42	1.00

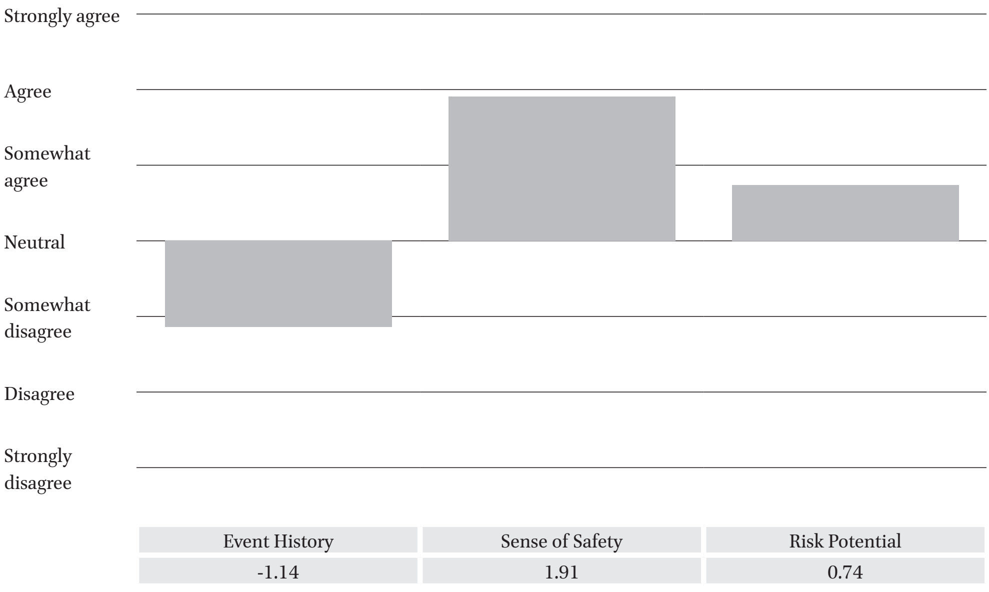
BAR CHART 15 Risk Reduction Capacity per business sector

15.6.3 *Safety*

15.6.3.1 General means for Safety

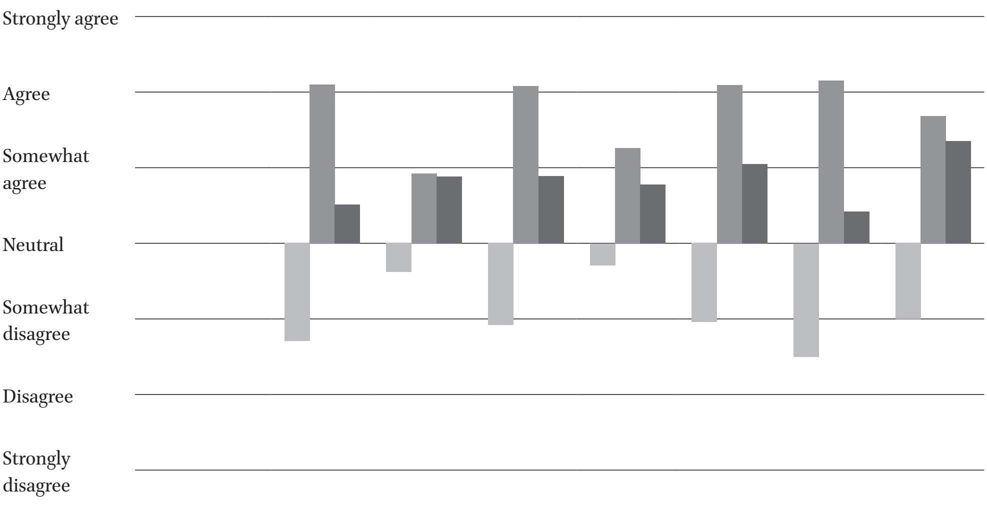
Result	Event History	Sense of Safety	Risk Potential
Valid	1906	2005	1991
Missing	1426	1327	1341
Mean	-1.1443	1.9102	0.7373
Std. Deviation	1.50995	1.24732	1.75591

TABLE 24 Safety as reported by general employees



BAR CHART 16 General safety as reported by general employees

15.6.3.2 Safety per business sector



	Tank storage (n=98)	Hospitals (n=211)	Process industry (n=48)	Oil & gas (n=96)	Infra general (n=436)	Rail infra (n=901)	Other (n=215)
Event History	-1.29	-0.38	-1.08	-0.29	-1.04	-1.50	-1.00
Sense of Safety	2.10	0.92	2.08	1.26	2.09	2.15	1.68
Risk Potential	0.51	0.88	0.89	0.78	1.06	0.42	1.35

BAR CHART 17 Safety per business sector

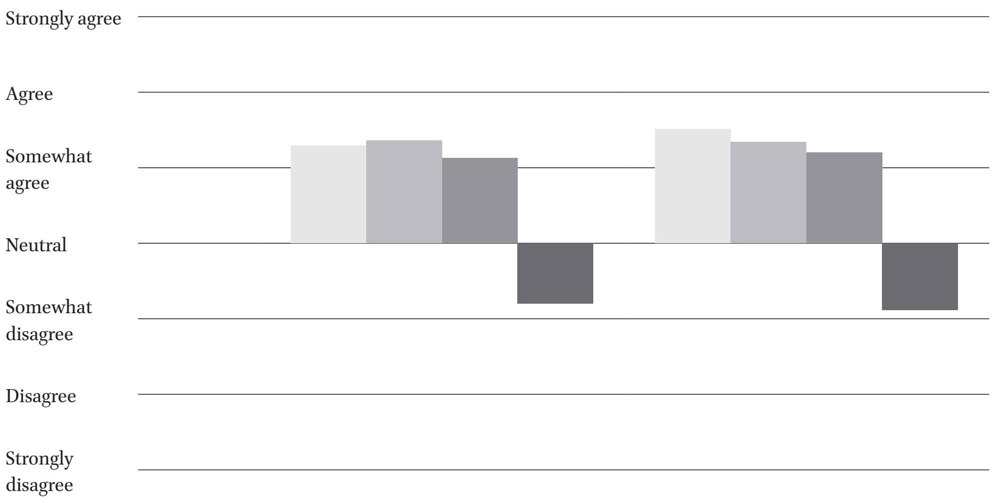
15.7 Mean scores for additional moderator variables

15.7.1 Mean scores by direct supervisors' genders

	Frequency	Percent
Male	2578	77,4
Female	720	21.6
Total	3298	99.0
Missing	34	1.0
Total	3332	100.0

TABLE 25 Genders of respondents' direct supervisors

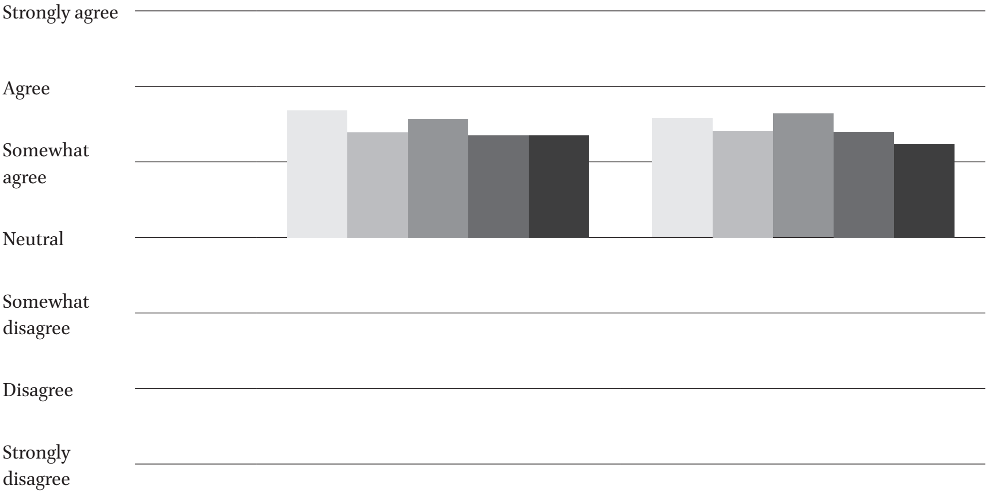
15.7.1.1 Safety Leadership orientations by gender of direct supervisors



	Men (n=2578)	Women (n=720)
Relation	1.29	1.51
Process	1.36	1.34
Production	1.13	1.20
Dominance	-0.80	-0.88

BAR CHART 18 Safety Leadership by gender of direct supervisors

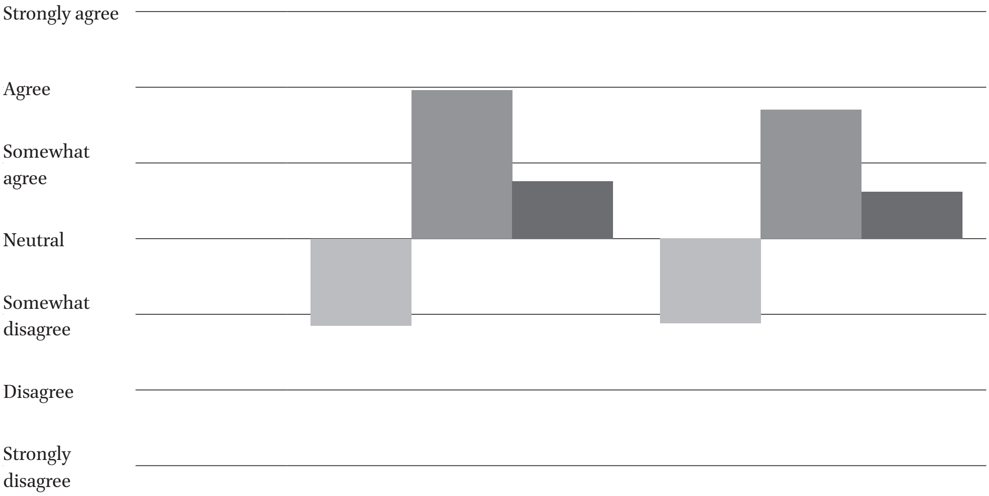
15.7.1.2 Risk Reduction Capacity by gender of direct supervisors



	Men (n=2578)	Women (n=719)
Recognition	1.68	1.58
Ability	1.39	1.41
Motivation	1.57	1.64
Courage	1.35	1.40
Action	1.35	1.24

BAR CHART 19 Risk Reduction Capacity by gender of direct supervisors

15.7.1.3 Safety by gender of direct supervisors



	Men (n=1640)	Women (n=364)
Event History	-1.15	-1.12
Sense of Safety	1.96	1.70
Risk Potential	0.76	0.62

BAR CHART 20 Safety by gender of direct supervisors

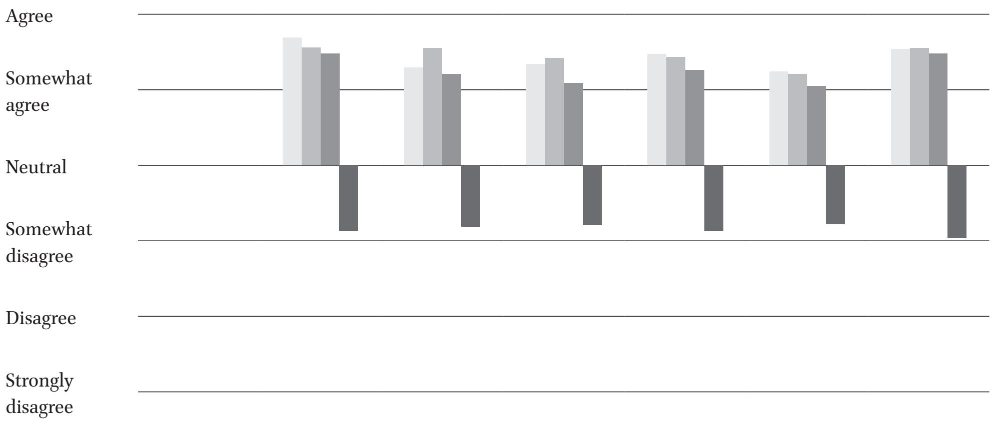
15.7.2 *Mean scores by hierarchical position*

Distribution of hierarchical positions

	Frequency	Percent
Director/Board	41	1.2
Management	340	10.2
Supervisor	657	19.7
Support staff	559	16.8
Operational staff	1539	46.2
Senior staff	181	5.4
Subtotal	3317	99.5
Missing	15	0.5
Total	3332	100.0

TABLE 26 Hierarchical positions of respondents

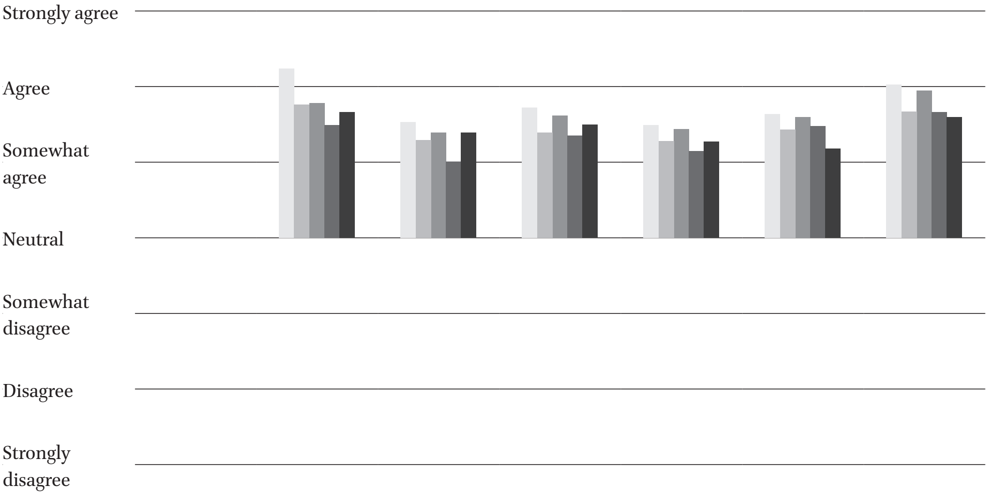
15.7.2.1 Safety Leadership by hierarchical positions



	Director (n=41)	Manage-ment (n=340)	Supervisors (n=657)	Support staff (n=559)	Operational staff (n=1539)	Senior staff (n=181)
Relation	1.69	1.29	1.34	1.47	1.24	1.54
Process	1.56	1.55	1.42	1.43	1.21	1.55
Production	1.48	1.21	1.09	1.26	1.05	1.48
Dominance	-0.87	-0.82	-0.79	-0.87	-0.78	-0.96

BAR CHART 21 Safety Leadership by hierarchical positions

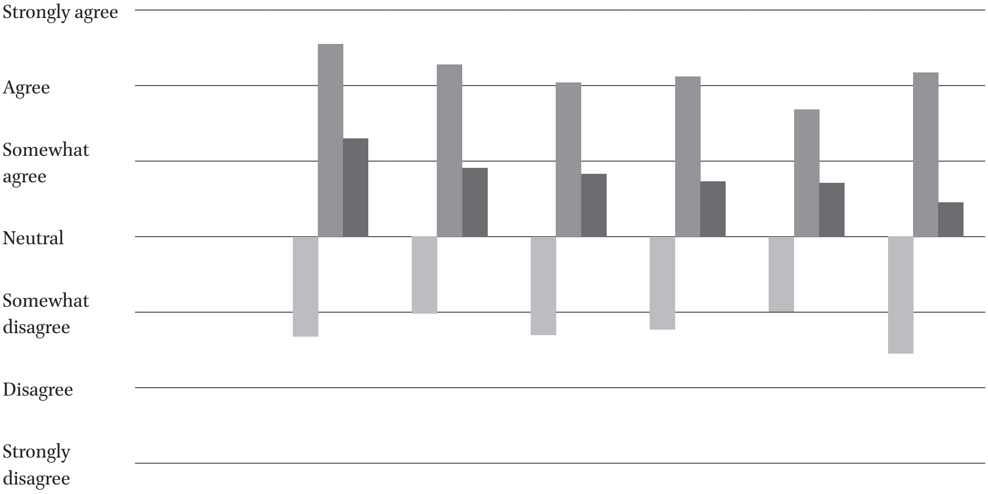
15.7.2.2 Risk Reduction Capacity by hierarchical positions



	Director (n=41)	Management (n=340)	Supervisors (n=657)	Support staff (n=557)	Operational staff (n=1535)	Senior staff (n=181)
Recognition	2.24	1.53	1.72	1.49	1.64	2.03
Ability	1.76	1.29	1.39	1.28	1.43	1.67
Motivation	1.78	1.39	1.62	1.44	1.60	1.95
Courage	1.49	1.01	1.35	1.15	1.48	1.66
Action	1.66	1.39	1.50	1.27	1.18	1.60

BAR CHART 22 Risk Reduction Capacity by hierarchical positions

15.7.2.3 Safety by hierarchical positions

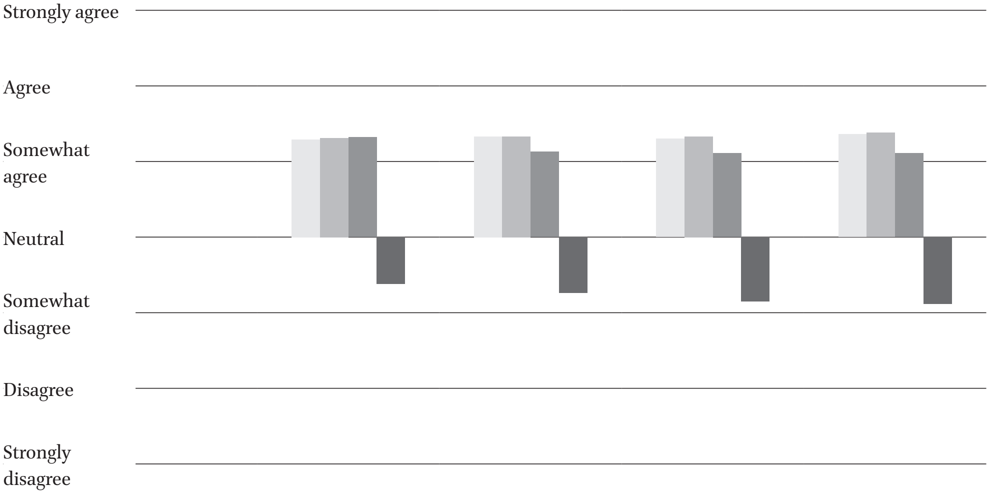


	Director (n=20)	Management (n=148)	Supervisors (n=366)	Support staff (n=325)	Operational staff (n=962)	Senior staff (n=179)
Event History	-1.32	-1.02	-1.30	-1.23	-0.99	-1.55
Sense of Safety	2.55	2.28	2.04	2.12	1.68	2.17
Risk Potential	1.30	0.91	0.83	0.73	0.71	0.45

BAR CHART 23 Safety by hierarchical positions

15.7.3 *Mean scores by age*

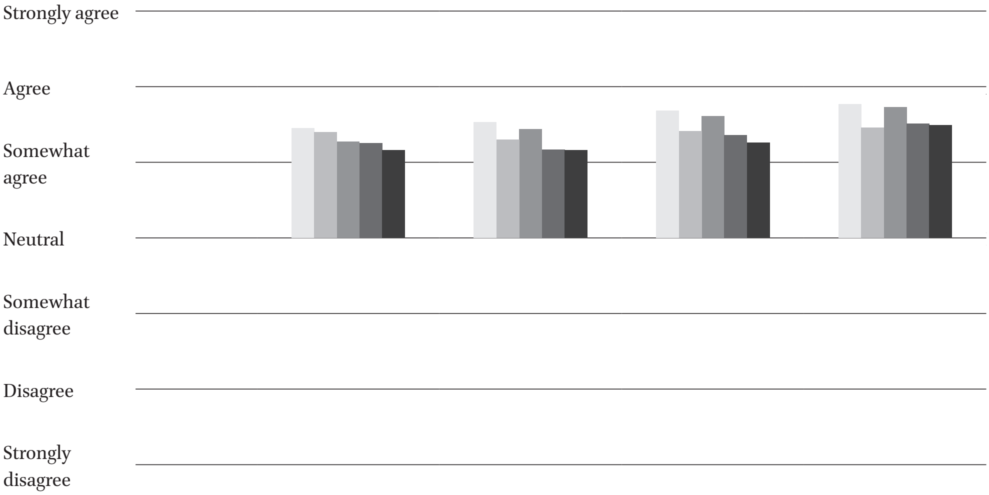
15.7.3.1 Safety Leadership by age



	Age < 31 (n=352)	Age 31–40 (n=737)	Age 41–50 (n=1001)	Age 51–67 (n=1229)
Relation	1.29	1.33	1.30	1.36
Process	1.31	1.33	1.33	1.38
Production	1.32	1.13	1.11	1.11
Dominance	-0.62	-0.74	-0.85	-0.88

BAR CHART 24 Safety Leadership by age

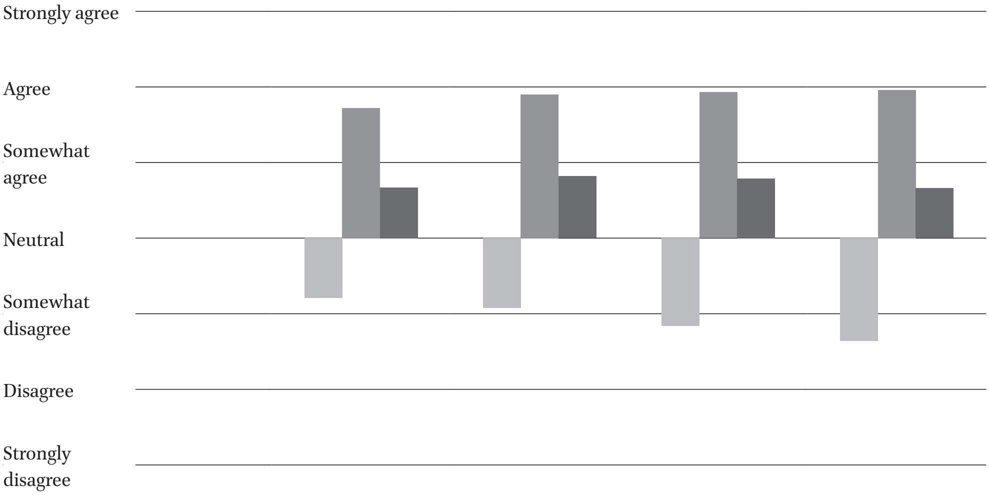
15.7.3.2 Risk Reduction Capacity by age



	Age < 31 (n=352)	Age 31–40 (n=735)	Age 41–50 (n=999)	Age 51–67 (n=1226)
Recognition	1.45	1.53	1.68	1.77
Ability	1.40	1.30	1.41	1.46
Motivation	1.27	1.44	1.61	1.73
Courage	1.25	1.17	1.36	1.51
Action	1.16	1.16	1.26	1.49

BAR CHART 25 Risk Reduction Capacity by age

15.7.3.3 Safety by age

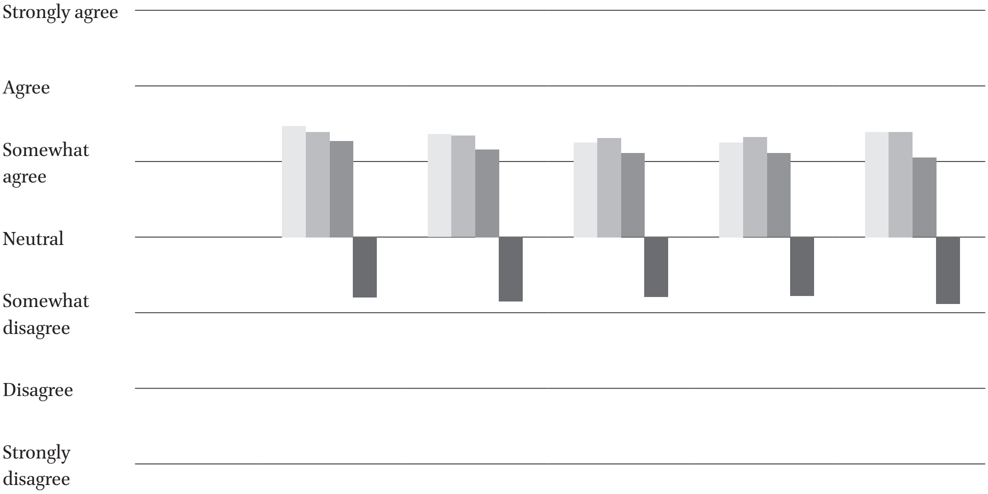


	Age < 31 (n=209)	Age 31–40 (n=439)	Age 41–50 (n=592)	Age 51–67 (n=756)
Event History	-0.79	-0.92	-1.16	-1.36
Sense of Safety	1.72	1.90	1.93	1.96
Risk Potential	0.67	0.82	0.79	0.66

BAR CHART 26 Safety by age

15.7.4 *Mean scores by vocational experience*

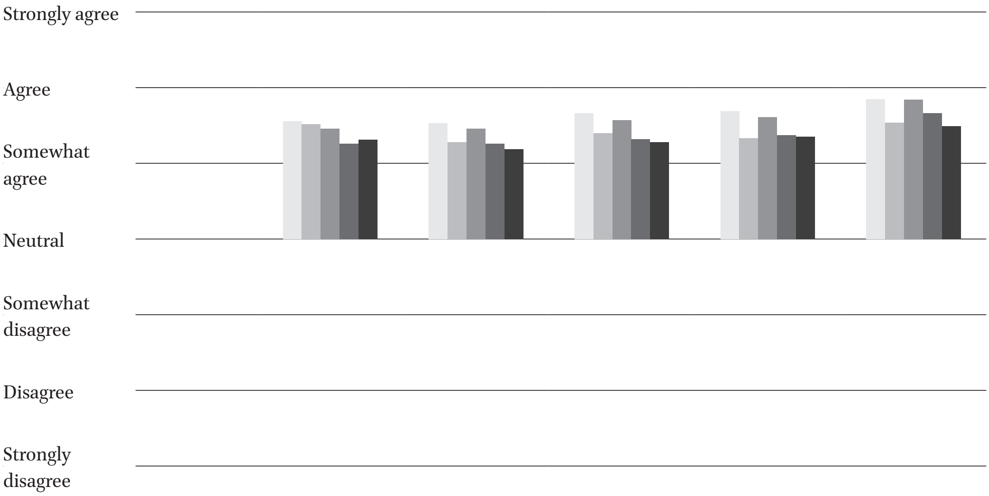
15.7.4.1 Safety Leadership by vocational experience



	0–5 years (n=546)	5–10 years (n=668)	11–20 years (n=883)	21–30 years (n=674)	31–50 years (n=548)
Relation	1.47	1.36	1.25	1.25	1.39
Process	1.39	1.34	1.31	1.32	1.39
Production	1.27	1.16	1.11	1.11	1.05
Dominance	-0.80	-0.85	-0.79	-0.78	-0.88

BAR CHART 27 Safety Leadership by vocational experience

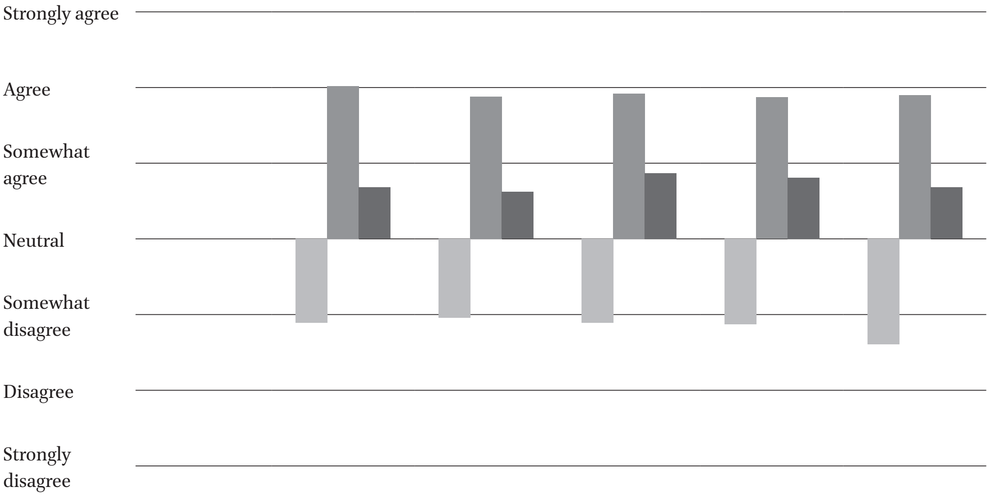
15.7.4.2 Risk Reduction Capacity by vocational experience



	0–5 years (n=545)	5–10 years (n=667)	11–20 years (n=880)	21–30 years (n=672)	31–50 years (n=547)
Recognition	1.56	1.53	1.66	1.69	1.85
Ability	1.52	1.28	1.40	1.33	1.54
Motivation	1.46	1.46	1.57	1.61	1.84
Courage	1.26	1.26	1.32	1.37	1.66
Action	1.31	1.19	1.28	1.35	1.49

BAR CHART 28 Risk Reduction Capacity by vocational experience

15.7.4.3 Safety by vocational experience

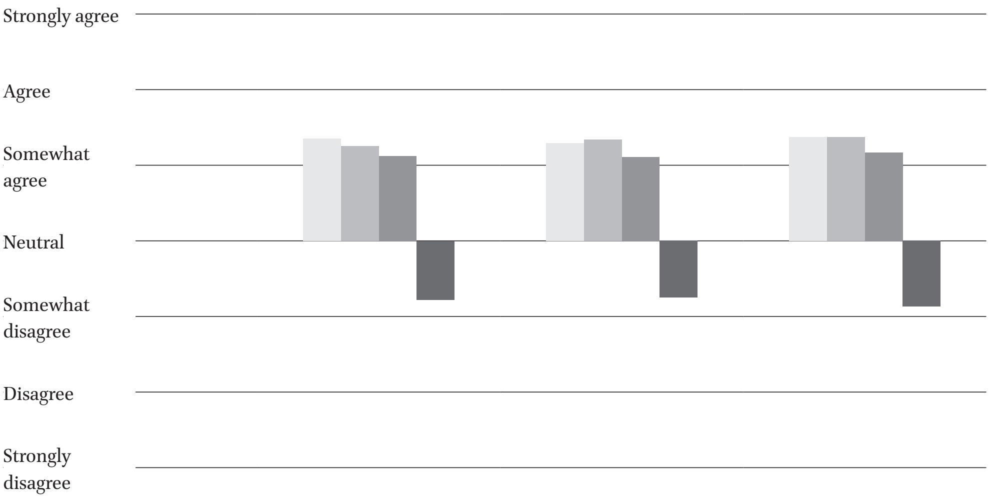


	0–5 years (n=324)	5–10 years (n=439)	11–20 years (n=492)	21–30 years (n=396)	31–50 years (n=348)
Event History	-1.11	-1.04	-1.11	-1.13	-1.39
Sense of Safety	2.02	1.88	1.92	1.87	1.90
Risk Potential	0.68	0.62	0.87	0.81	0.68

BAR CHART 29 Safety by vocational experience

15.7.5 *Mean scores by safety incident history*

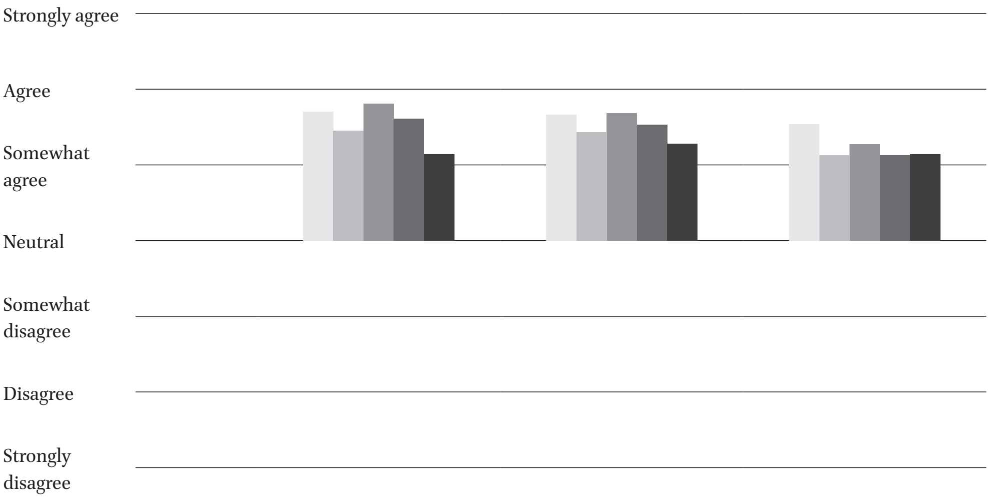
15.7.5.1 Safety Leadership by safety incident history



	Victim (n=233)	Witness (n=1293)	Neither (n=1772)
Relation	1.35	1.29	1.37
Process	1.25	1.34	1.37
Production	1.12	1.11	1.17
Dominance	-0.78	-0.75	-0.87

BAR CHART 30 Safety Leadership by safety incident history

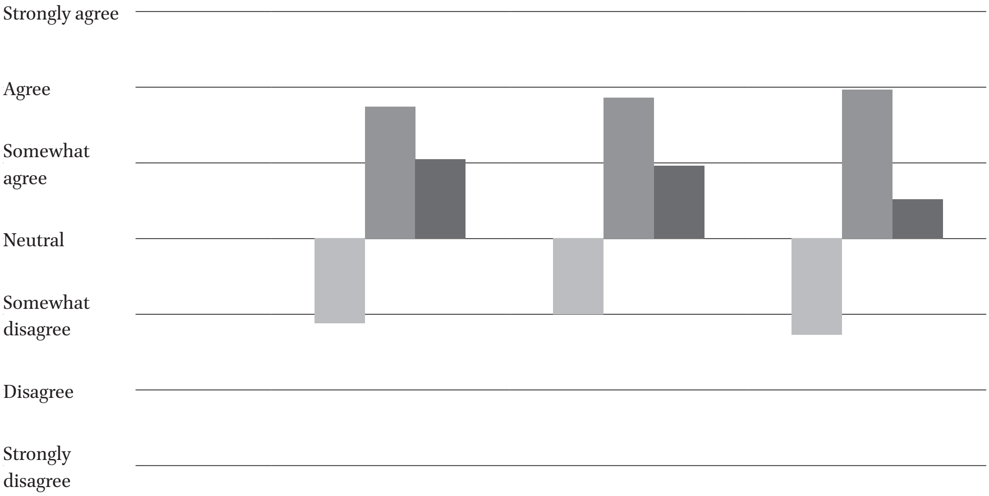
15.7.5.2 Risk Reduction Capacity by safety incident history



	Victim (n=232)	Witness (n=1292)	Neither (n=1767)
Recognition	1.70	1.66	1.54
Ability	1.45	1.43	1.13
Motivation	1.81	1.68	1.27
Courage	1.61	1.53	1.13
Action	1.14	1.28	1.14

BAR CHART 31 Risk Reduction Capacity by safety incident history

15.7.5.3 Safety by safety incident history



	Victim (n=140)	Witness (n=821)	Neither (n=1043)
Event History	-1.12	-1.00	-1.27
Sense of Safety	1.74	1.86	1.97
Risk Potential	1.05	0.96	0.52

BAR CHART 32 Safety by incident history

15.8 Conversation guide for reflection by senior leaders

Objective and method

Interviews with CEO/managing director, operational manager and safety manager.

To obtain the reflection by the interviewee about the results of questionnaire in terms of the Risk Reduction Cycle and Safety Leadership orientations as collected in his/her organisation.

Duration: Approx. 1 hour Location: Office of the interviewee

References

What is the response to the results of the survey with regard to the Risk Reduction Cycle and behavioural orientations of leaders?

Risk Reduction Cycle
- Understanding /Kennen
- Ability /Kunnen
- Motivation /Willen
- Courage /Durven
- Action /Doen

Safety Leadership orientations
- Task
- Relation
- Self

Results

Striking results?

What results are expected and what are unexpected?

Comments?

Follow up

What can/do you want with the results?

Own experience: Have you ever been directly/indirectly involved in a “calamity”?

Organisation code	**Date/time of interview:**					
Position of interviewee						
Number of years in sector						
Number of years in office						
Age	35–40	40–45	45–50	50–55	55–60	>60
M/F						

15.9 Effects of Safety Leadership on risk reduction phases

By application of Structural Equation Modelling (SEM), we identified the standardised regression coefficients of the effect of the four Safety Leadership orientations on risk reduction. The results of this analysis are shown in below Table 27.
The shaded cells indicate that there is no effect for these specific coordinates.

	Effects on Risk Reduction Phases				
	Recognition	**Ability**	**Motivation**	**Courage**	**Action**
Relation	-0.25				-0.26
Process	0.72	0.59	0.42	0.61	0.79
Production	-0.18	-0.17			-0.19
Dominance					

TABLE 27 Standardised regression coefficients of effects of Safety Leadership on Risk Reduction

15.10 Mediating effects of risk reduction phases on Safety.

By application of Structural Equation Modelling (SEM), we identified the standardised regression coefficients (or standardised loadings) of the effects of each individual risk reduction phase on the three characteristics of the Safety node of the Safety Leadership Model (Event History, Sense of Safety and Risk Potential). The referred results are presented in the table below (Table 28). All effects less than 0.10 are considered too weak to be considered and are ignored. The shaded cells contain the ignored effects.

	Event History	Sense of Safety	Risk Potential
Recognition	-0.16	0.14	-0.06
Ability	-0.16	0.14	-0.05
Motivation	-0.12	0.08	-0.05
Courage	-0.16	0.07	-0.07
Action	-0.18	0.16	-0.09

TABLE 28 Standardised regression coefficients of effects of risk reduction phases on Safety

15.11 Direct and indirect influences of Safety Leadership on Safety

	Indirect (mediated) effect															Direct effect		
	Recognition			Ability			Motivation			Courage			Action			Event History	Sense of Safety	Risk Potential
	E	S	R	E	S	R	E	S	R	E	S	R	E	S	R	E	S	R
Relation	.04	-.004											.05	-.04		.33 – .38		
Process	-.12	.10		-.09	.08		-.05	.03		-.09	.04	.04	-.14	.12	-.07	-.43 – -.52	.35 – .44	
Production	.03	-.03		.03	-.02								.03	-.03		.17 – .19		
Dominance																.37 – .38		.22 - .24

TABLE 29 Standardised regression coefficients of influences of Safety Leadership on Safety

LEGEND: E=Event History S=Sense of Safety R=Risk Potential
Green =noticeable effect
Grey =no significant effect
Blank =negligible effect

15.12 Sources versus Process-oriented Safety Leadership Principles

In this appendix we explain how the different sources (the behavioural characteristics of Process-oriented leaders, the Academic Safety Leadership Practices and the findings by Flin and Hale et al.) have been applied to develop the Process-oriented Safety Leadership Principles as presented in paragraph 11.2.2.3.

Below we show a numbered list of all Academic Safety Leadership Practices plus the findings by Flin and Hale et al. We used this list to develop a table showing which item served as source for each Process-oriented Safety Leadership Principle. This table is presented after the numbered list.

15.12.1 *List of source items (numbered)*

LEGEND OF CODES after text:

G=Growth Mindset
PS=Psychological Safety
HRO=High Reliable Organizing
TL=Transformational Leadership
Flin=Item mentioned by Flin
Hale=Item mentioned by Hale et al.

Numbers shown after source items refer to related Process-oriented Safety Leadership Principle.

1. In selection and hiring processes, looking for people who are filled with passion and a desire to get things done. **G2**
2. Welcoming change and new ideas regardless of their source. **G7**
3. Being understanding and supportive when things have gone different as envisaged and helping employees through, acting as a guide, not as a judge. **G6**
4. Shutting down elitism and getting rid of brutal 'bosses'; fostering productivity by mentoring. Talking journey, instead of royalty, limiting the use of the words 'I' and 'me'; using 'we' and 'us' instead. Rewarding teamwork rather than individual genius. **G6**
5. Managers visiting operational sites to chat with front-line employees frequently. **G6**
6. Opening up dialogue and channels for honest feedback; asking team members what they like and dislike about the company and what they think needing change, e.g., by setting up structures, processes and forums for input and providing guidelines for discussion. **G6 + PS6**
7. Showing that the analyzed values and stimulates personal development and growth of employees. **PS2 + PS3**
8. Emphasizing purpose by identifying what is at stake, why it matters and for whom. **PS1**

9. Clear framing of work by setting expectations about failure, uncertainty and interdependence to clarify the need for voice. **PS4 + PS3**
10. Inclusion of all team members, through *direct invitation*, in discussions and decisions in which their voices and perspectives might otherwise be absent. **PS6**
11. Supporting collaboration across organisational boundaries by inviting input from relevant operational competence and experience in all meetings and consultations, ignoring hierarchy and departmental barriers. **PS6 + PS3**
12. Demonstrating situational humility by acknowledging gaps in own performance. **PS4**
13. Fostering a just culture by focusing on system flaws, not on individuals, but sanction clear violations. **PS7**
14. Destigmatizing failure by looking forward, offering help, discussion, consideration and brainstorming next steps. **PS6 + PS3**
15. Stimulating reporting of safety risks and operational disturbances and express appreciation by listening, acknowledging and thanking for communicating. **PS7**
16. Practicing inquiry by asking good questions and listening intensively. **PS6**
17. Considering that changes taking place at any hierarchical level, these must be supported by concomitant change at other levels. **TL8**
18. Intervention models must assume a multi-level perspective, because processes take place at any organisational level influence and are influenced by, adjacent levels, i.e., processes at different levels are interconnected. **TL8**
19. Deliver incentives as part of their daily routine. Weekly feedback to line-supervisors concerning the frequency of safety-oriented interactions with subordinates, accompanied by communication of (high) safety-priority from direct superiors (i.e., section managers). **TL6**
20. Feedback concerned randomly timed episodic interviews with subordinates. During interviews, workers described their most recent interaction with their supervisor. **TL6 + TL3**
21. Emphasize that incentives delivered by superiors (e.g., personal attention and recognition) have consistently been shown to provide the strongest reinforcement value in the organisational context, surpassing material and social incentives. **TL6**
22. leaders dare to discuss identified normalized deviant behaviour with their followers. **HRO6**
23. leaders should not avoid debates about the (ignorance of) seemingly unimportant deviations from normal, also known as ‘weak signals.’ **HRO7**
24. Identify whether there are variances in operation procedures between departments, sites or time periods (e.g., days/nights, weekends, holidays). **HRO7 + HRO3**
25. an open dialogue between all relevant operating and supervisory staff is easily facilitated in order to find the reasons why the identified differences exist. **HRO6**
26. leaders should be alert concerning team members who are often absent when it comes to evaluating, reflecting and learning. **HRO7**

27. Leaders be aware and respect that unknown risks (blind spots) may exist and also motivate their team members to take this into account during their operations. **HRO7 + HRO3**
28. Leaders should respond positively, should verify the message and be prepared to take timely all remedial actions needed to prevent escalation. **HRO8**
29. "Expect the unexpected and always assume that during operations something can go wrong!" **HRO7**
30. As in any other facet of management, what is critical is the behaviours that are demonstrated in relation to safety. **Flin7**
31. Especially time is a crucial factor as it is the strongest signal of commitment by busy managers with little time to spare. **Flin6**
32. Show the importance of the safety professional and top management support as '**motor**' for the successful implementation of safety interventions. **Flin5**
33. The importance of dialogue between the workforce and line-management as the most essential factor in ensuring that analyzed learn and change. Central to this dialogue was the reporting of dangerous situations (Recognition!). **Hale6** + **Hale3**
34. most successful companies in the study, were the companies where the workforce and managers were more actively encouraged to look for safety risks; these companies showed spectacular increases in numbers. **Hale7** + **Hale3**
35. Rewarding reporters of (perceived) safety risks by ensuring that all reports are analyzed and decisions on remedial actions taken on them and that the reporters would receive feedback on actions taken (even if that feedback was to explain the reasons for lack of action). **Hale8**
36. The workforce was empowered to refuse to work under unsafe conditions. **Hale4** + **Hale3**
37. Top and line-managers were offered safety leadership training. **Hale5**

15.12.2 *Reference table: Sources of Process-oriented Safety Leadership Principles*

PROCESS-ORIENTED SAFETY LEADERSHIP PRINCIPLE	Process-oriented characteristic	Flin	Hale	HRO	Psychological safety	Growth mindset	Transformational leadership
1. Don't skimp on safety	A				8		
2. Assure a sufficient number of competent staffing	A				7	1, 4	
3. Enable all employees to perform their duties in a safe way	A		33, 34, 36	24, 27	7, 9, 11, 14		20
4. Empower employees to refuse to work under unsafe conditions	C, D		36		9, 12		
5. Arrange professional safety leadership training for all leaders at all levels	A	32	37				
6. Allocate sufficient time for dialogues with workforce at their workplaces	A, C	31	33	22, 25	6, 10, 11, 14, 16	3, 4, 5,6	19, 20, 21
7. Actively encourage identification and communication of safety hazards	C	30	34	23, 24, 26, 27, 29	13, 15	2	
8. Monitor implementation and achieved effects of risk reducing measures	B		35	28			17, 18

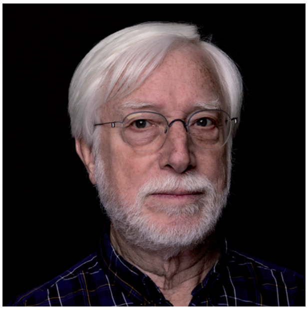
TABLE 30 Sources of Process-oriented Safety Leadership Principles

LEGEND: *Process-oriented characteristics*

A. Sincerely care for safety
B. Ensure that necessary improvements are implemented timely
C. Motivate team members to intervene to prevent safety incidents
D. Forgive people who intervene by mistake

Numbers refer to source items (listed under previous paragraph 15.12.1)

Curriculum vitae



Victor Roggeveen (Amsterdam, 1949) joined the Royal Netherlands Navy in 1965 and was trained as a ship's engineer. He resigned after 8 years of service to accept an offshore technical position in an oil company operating a gas exploration activity in the southern North Sea (1973). Two years later, after the company obtained a gas production license, he was assigned as the first company's 'safety man' offshore. After 9 years of experience in the safety profession, he resigned in order to found his own independent safety consultancy firm Advi-Safe Consultants (1984). This company rendered safety consultancy services to high-risk organisations in the oil and gas, tank storage, railways and other industries on a global scale. Under his supervision, the company developed safety management systems, safety incident investigations and conducted safety related training courses. In the year 2000 he retired from Advi-Safe Consultants. Since then, Victor operates as an independent risk management consultant, Tripod trainer and incident investigator, with a focus on the health care sector (hospitals) and other high-risk industries.

Since 1995 he holds a professional master degree in Occupational Health, Safety and Welfare from Amsterdam University (UvA). From 2006 until 2012 he chaired the Dutch Society of Safety Practitioners (NVVK). In 2013 he enrolled the Dual PhD Centre of Leiden University to do PhD research into the influence of leaders on the prevention of safety incidents.