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DESIGNING A MAP FOR ANALYZING AND MEASURING SAFETY PERFORMANCE

Master of Science Thesis
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ABSTRACT

Roosa Haapavirta: Designing a map for analyzing and measuring safety performance
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Occupational health and safety (OHS) has been found to have a significant impact on an organization's performance, which is why successful safety management and performance management are essential in companies. Challenges for management are posed by the large amount of measurement data related to workplace safety. The overall picture of the factors related to the improvement of occupational health and safety is unclear, and the efficiency of the indicators is not fully known. This master's thesis studies how safety performance can be modeled visually as a map. The research aims to identify factors that affect a company's safety performance, understand the relationships between these identified factors, and study how the factors can be measured.

The theoretical part of the study is a literature review that examines previous academic research on the topics of safety management and performance measurement. A general level theoretical framework that describes the perspectives influencing safety performance is created based on the literature findings. The framework was supplemented in the empirical phase of the study by a more detailed description. Also, the theory of measuring safety performance was studied. It was found that the literature recommends emphasizing the use of proactive indicators in safety management.

The empirical part of the study was conducted as a qualitative multiple case study. Four companies from different industries participated in the creation of the safety performance map, and the map was later tested in three companies. The qualitative material of the research consisted of the notes of the workshops organized during the research project.

The study identified a wide range of factors affecting safety performance and found relationships between some of them. The factors were found to be broadly the same in different industries. However, the factors were found to be specified or emphasized depending on the industry, size, geographical fragmentation, stage of the company's life cycle, and the company's safety maturity. Based on the study, the current safety measurement in companies focuses on measuring only a few factors, and proactive measures are lacking. The study presents examples of proactive leading, qualitative indicators identified in the literature. The proposed indicators can be used to measure the factors more accurately.

Keywords: Occupational health and safety, safety performance, safety management, indicators, performance management

TIIVISTELMÄ

Roosa Haapavirta: Kartan kehittäminen turvallisuussuorituskyvyn analysoinnin ja mittaamisen tueksi
Diplomityö, 92 sivua, 4 liitettä
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Työterveydellä ja -turvallisuudella (jatkossa turvallisuus) on havaittu olevan merkittävä vaikutus organisaation suorituskykyyn, minkä vuoksi työturvallisuuden ja suorituskyvyn onnistunut johtaminen on yrityksissä olennaista. Haasteita johtamiselle aiheuttaa työpaikkojen turvallisuuteen liittyvän mittaustiedon suuri määrä. Kokonaiskuva työturvallisuuden parantamiseen liittyvistä tekijöistä on epäselvä ja eikä mittareiden vaikuttavuutta täysin tunneta. Tässä diplomityössä tutkitaan, kuinka turvallisuussuorituskykyä voidaan mallintaa visuaalisesti kausaalisuhteita esittävän kartan avulla. Työn tavoite on selvittää tekijät, jotka vaikuttavat yrityksen turvallisuustasoon, ymmärtää näiden tunnistettujen tekijöiden välisiä suhteita ja tutkia, kuinka tunnistettuja tekijöitä voidaan mitata.

Tutkimuksen teoria perustuu akateemisen kirjallisuuden tarkasteluun turvallisuuden johtamisen ja suorituskyvyn mittaamisen aloilta. Projektitutkimuksessa luotiin teoriaan pohjautuen turvallisuussuoritustason muodostumiseen vaikuttavia tekijöitä kuvaava yleisen tason viitekehys. Tätä viitekehystä syvennettiin diplomityön empiirisessä osiossa yksityiskohtaisemmaksi kuvaukseksi. Teoriaa tarkasteltiin lisäksi turvallisuussuorituskyvyn mittaamisen valossa. Tutkimuksessa havaittiin kirjallisuuden suosittelevan painottamaan turvallisuusjohtamisessa ennakoivien mittareiden käyttöä.

Tutkimuksen empiirinen osio toteutettiin laadullisena monitapaustutkimuksena. Turvallisuussuorituskyvyn kartan luomiseen osallistui neljä yritystä eri toimialoilta ja lisäksi karttaa testattiin kolmessa yrityksessä. Tutkimuksen laadullinen aineisto koostui tutkimuksen aikana järjestettyjen työpajojen muistiinpanoista, minkä lisäksi työssä hyödynnettiin ennen diplomityötutkimuksen aloittamista järjestetyistä työpajoista kerättyä aineistoa.

Tutkimuksessa tunnistettiin laaja joukko turvallisuustasoon vaikuttavia tekijöitä ja osan tekijöistä välille löydettiin syy-seuraussuhteita. Tekijöiden havaittiin olevan pääpiirteittäin samoja eri teollisuuden aloilla. Tekijöiden havaittiin kuitenkin täsmentyvän eri tavoin yrityksen toimialasta, koosta ja organisaation turvallisuustason kypsyystilasta riippuen. Tutkimuksen perusteella vaikuttaa, että yritysten nykyinen mittaaminen painottuu ainoastaan muutaman turvallisuuteen vaikuttavan tekijän mittaamiseen eikä ennakoivia mittareita ole laajalti käytössä. Tutkimuksessa esitetäänkin esimerkkejä kirjallisuudesta löytyvistä ennakoivista, laadullisista mittareista, joiden avulla eri tekijöitä voidaan mitata täsmällisemmin.

Avainsanat: Työterveys ja -turvallisuus, turvallisuussuorituskyky, työturvallisuusjohtaminen, mittarit, suorituskyvyn johtaminen

PREFACE

The spring of 2020 will be remembered. I will remember the spring as the time when I finished my five-year studies at university by writing this thesis. However, I and the rest of the world will also remember the spring as a time when the global pandemic Covid-19 shook our daily lives and our usual way of life. I did not write my thesis as planned in the office, but on the home couch and kept in touch with the examiners and research participants mostly virtually.

I would like to thank my examiners Senior Research Fellow Aki Jääskeläinen and University Teacher Sari Tappura for the valuable feedback and instructions and the case companies for their time and valuable input to the study.

During this exceptional time - and at all times before and hopefully in the future - my greatest support has been the great people around me. Thank you for my family, thank you Lari. You are dear to me. Thank you also for my fellow students. Especially grateful I am for the network of women of my class year. I hope our friendship lasts a lifetime.

Although the effects of the spring, which turned to exceptional due to the pandemic, are far-reaching, especially in the fields of economy and manufacturing, I look to the future and my career with confidence and enthusiasm.

Tampere, 1 September 2020

Roosa Haapavirta

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LIST OF SYMBOLS AND ABBREVIATION

EU-OSHA	European Agency for Safety and Health at Work
H&S	Health and Safety
HSE	Health, Safety and Environment
HSEQ	Health, Safety, Environment and Quality
KPI	Key Performance Indicator
LTA	Lost Time Accident
LTIFR	Lost Time Injury Frequency Rate
LTI	Lost Time Injury
NOSACQ-50	Nordic Occupational Safety Climate Questionnaire
MTI	Medical Treatment Incident
OHS	Occupational Health and Safety
OHSMS	Occupational Health and Safety Management System
OSH	See OHS
PMS	Performance Measurement System
RQ	Research Question
SHW	Safety, Health and Wellbeing
SIF	Serious Incidents and Fatality
TRI	Total Recordable Injury
TRIFR	Total Recordable Injury Frequency Rate

1. INTRODUCTION

1.1 Background

Occupational health and safety (OHS) management, often also referred shortly as safety management, is known to positively affect safety performance, competitiveness performance, and economic-financial performance (Fernández-Muñiz et al. 2009). Also, Köper et al. (2009) have identified a relationship between occupational health and safety and overall business performance and competitiveness. They report the interconnection between employee health-related issues and key performance factors, such as quality, productivity, cost reduction, and absenteeism. While successful safety management benefits are known, there are challenges in realizing the full potential of performance measurement (Bititci et al. 2011) that strongly guide management activities. The overall picture of the factors that contribute to improving occupational safety - and thereby improving the performance of the entire organization - remains unclear.

The influence of different factors on the formation of safety performance has been previously studied in the literature. Wu et al. (2008) found an interconnection between safety leadership, safety climate, and safety performance. They state that other factors, such as organizational leadership, organizational culture, safety culture, and organizational performance, may all affect safety performance, but this aspect needs more research to confirm and generalize the findings. According to Blair (2003), safety culture and leadership must both be improved to influence safety performance positively. Aksorn et al. (2008) go more in detail, stating that the most influential factor affecting safety performance is management support. However, although existing literature has identified factors affecting the safety performance, in the current models, the emphasis has been mainly on these separate components rather than describing the whole cause-effect chain influencing the safety performance. Thus, there is an identified demand for further research that examines the factors affecting safety performance on a broader scope.

One study about the causal chains of OHS and the business performance is a research of Köper et al. (2009), where they studied the theme in an automobile manufacturing company. They found cause-effect relationships, but the different components in the model they reported remain somewhat generic. They were not able to provide a very detailed description of the factors contributing to performance, as such detail level factors

often appeared in the study only as individual cases, and the findings could not, therefore, be generalized. Also, the subject was studied only in one rather niche industry, and thus, it would be interesting to see how the results would differ if different industries were involved in the research.

Identifying occupational safety-related factors and their interactions is an important research subject, as it helps to understand how safety interventions and improvements can impact the organization's OHS performance. If the causal chain leading from OHS-related factors to OHS performance is not clearly understood, there is a risk for ineffective safety interventions. (Cagno et al. 2011) The challenge is that the interventions to improve occupational safety are multidimensional, which is why explicit before and after assessments of their effect on performance is difficult (Hale et al. 2010). This aspect can be seen to indicate that there is a need for investigating which factor contributing to the safety performance the interventions effect on. According to Köper et al. (2009), more research is required in particular to find suitable targets and measures for the different components of the safety performance causal chain to develop the measurement of safety performance.

There are numerous uses to take advantage of performance measurement in management work. Performance measurement is used to plan, control, and lead the work of the organization (Cousins et al. 2008, p. 242). Managers can utilize performance measurement to demonstrate the company's objectives to employees and motivate them to achieve these goals, justify rewarding, monitor the progress of the business, benchmarking to competitors' positions, and communicate performance to internal and external stakeholders (Neely 1998, p. 71-89). Even though performance measurement is considered advantageous, there are some challenges in efficiently executing measuring and data utilization. Overall, organizations seem to be having difficulties in turning measuring data into action (Sinelnikov et al. 2015).

Initially, performance measurement focused on financial information, but more recently, one of the research topics of performance measurement that has attracted increasing interest has been the measurement of intangibles (Petty and Guthrie 2000). However, measuring the value of intangible elements such as employee skills, employee well-being, company image, customer relationships or safety is often considered difficult (Lönnqvist 2004, p. 23; Tappura et al. 2015). In fact, in the context of safety performance measurement, it is the proactive performance measures in intangible elements that appear to be most effective in influencing occupational safety and preventing accidents (Vredenburgh 2002; Haslam et al. 2016). Recently, interest in proactive measures, also

known as leading indicators, has increased in both the literature and business (e.g. Hinze et al. 2013).

1.2 Research objectives and questions

The objective of this thesis is twofold. Firstly, the study aims to determine the various factors that influence a company's safety performance and understand the relationships between these identified factors. The work focuses particularly on the perception of measurement objects relevant to proactive measurement, as the need for developing and emphasizing proactive measurement in occupational safety management has been identified both in the literature and in the case companies involved.

Once the measurement objects that affect safety performance have been identified, the study seeks to identify indicators for measuring these different factors. Like the identification of measurement objects, the focus is also especially in the development of new performance measures in intangible elements that are crucial for preventing harm. The presented indicators and their usefulness are to be evaluated more closely in one case company.

Consequently, the following questions are addressed as research questions:

> ***RQ1.*** *What are the key factors affecting safety performance?*
>
> ***RQ2.*** *How can the factors affecting safety performance be measured?*

To answer the first research question, this thesis aims to introduce a safety performance map, a framework that illustrates perspectives and more detailed factors affecting safety performance and their relation to each other. The purpose of creating safety performance maps is to provide companies a tool for identifying the mechanisms of improving safety performance. Maps are to be utilized in analyzing and reporting performance, as well as in the identification of development targets in performance measurement. The idea is that the map will reveal the coverage of the current measurement of companies in relation to the representation of performance factors on the map. Also, the map can be used to evaluate performance measurement status and support the implementation of safety strategies. The map presents the result (e.g., financial performance) to which different causes are linked (e.g., employee welfare, management commitment).

The map is then supplemented by linking the existing safety performance measures used in the four case companies surveyed and the measures used in the companies involved in the testing of the map to each of the safety performance perspectives. The list is then

further supplemented with the measures identified from the literature. The previous aspects are done to answer the second research question. The aim is to create a universally valid model describing the safety performance and present a list of universal indicators for the benefit of companies from different industrial sectors. Moreover, a comprehensive and concrete study is conducted in one of the case companies to assess the usefulness of the proposed indicators.

1.3 Research context and scope

This thesis is done as a part of the SafePotential research project. The SafePotential project is a two-and-a-half-year (1/2019-6/2021) research and development project of performance measurement in support of safety management. The project is part of a more extensive European Saf€ra research program, and thus, it involves researchers also from the University of Belgrad and the University of Twente. The project is funded by the Finnish Work Environment Fund, Tampere University, and four case organizations partaking to the research.

The motivation for this study stems from the need for research identified in the literature as described above, but also from the practical demands and wishes of the project's case organizations. The scope of this thesis is not restricted to certain industrial sectors or sizes of organization, but the four Finnish companies involved all represent different industries. The companies represent manufacturing and service of cranes and lifting equipment, infrastructure sector, food industry, and environmental, facility, and industrial support services. In the food industry company, a more comprehensive research is carried out. With the company, the findings of the study are assessed in more detail. In addition to the actual case companies, three companies, again from different industries, will participate in the test phase of the study. A diverse set of sectors provides useful information about industry-specific features and, on the other hand, confirms the generalizability of the findings.

Although safety can be discussed in terms of different aspects in the organizational and corporate context, this thesis's scope is restricted to occupational health and safety. The SafePotential project and this thesis focus on the research of performance measurement in support of safety management. Therefore, occupational health and safety is approached specifically from a management perspective. Even though management can be considered to include leadership, these aspects are discussed separately in this study. The distinction between management and leadership is considered notable, as the research aims to determine the detailed factors contributing to a company's safety

performance. Besides, leadership has typically received less attention in the OHS management literature (Tappura 2017, p. 31), and therefore this study seeks to emphasize this aspect. However, since the manager cannot manage without the persons to be directed, the employees and especially their attitudes and beliefs, so culture, is part of the OHS management scope. Because a company's goal is ultimately to make a profit for its owners and management aims to improve the performance leading to this; also the economic effects occupational health and safety management are included in the scope.

1.4 Structure of the thesis

This study begins with a literature review presented in the following three chapters. First, the key concepts of this study are briefly defined. Then the theory of management of occupational health and safety is reviewed to get a general understanding of the theme. Subsequently, Chapter 4 first examines the theory of performance measurement at a general level and then goes deeper into the measurement of safety performance and particularly to the practice of proactive measuring.

The fifth chapter discusses the methodological choices of this research. Also, the data collection methods and the research process are described in detail. After that, the empirical part follows. The sixth chapter presents the analysis and the results of empirical research, that consist of two different parts. The chapter first answers the first research questions by presenting the created safety performance map and measurement findings. The latter part of the empirical research focuses on evaluating how the findings of the research work in practice through testing and discussions carried out in one of the case companies.

At the end of the study, the discussion is presented in the seventh chapter and is followed by conclusions in Chapter 8. This chapter summarizes the main findings of the research and presents an evaluation of research reliability and validity. The chapter also discusses the utilization of research results from a business perspective and considers the limitations and conditions for the use. The need for further research is considered by presenting further research proposals.

2. KEY CONCEPTS

2.1 Occupational health and safety

Safety is considered as freedom from unacceptable risk or harm (ISO/IEC 2004). In this thesis, safety is examined in the occupational context. In this context, safety is commonly referred to as occupational safety and health (OSH), occupational health, occupational safety, or occupational health and safety (OHS). OHS concerns the physical and mental health and safety of people in working environment. It can be defined more precisely as conditions and factors which have or may have an effect the health and safety of workers or anyone else at the workplace (BS 18004:2008). In this research, the term safety is commonly used instead of occupational health and safety and OHS to mean health, safety, and welfare issues in the workplace.

The largest employers' association in Finland, the Confederation of Finnish Industries (EK) (2016), has developed a corporate safety model, and occupational health and safety is described to be one part or a sector in the model. The different sectors in the model provide a basis for understanding and examining the company's overall safety. The model is presented below in Figure 1.

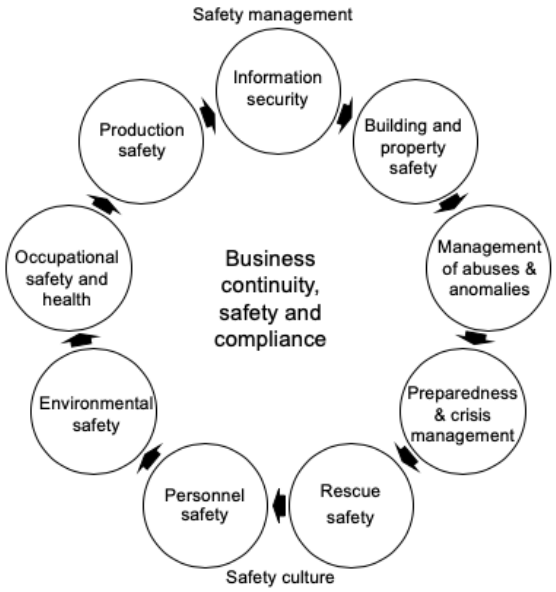


Figure 1. *Corporate safety (modified from Confederation of Finnish Industries (EK) 2016).*

For the purposes of this study, safety refers above all to occupational safety and health. This research also touches on the topics of production safety, process safety, product and service safety, and environmental safety, as the occupational safety and health cannot entirely be isolated from the other themes. However, these themes are not in the main scope of the study.

Occupational health and safety can be compromised due to an occurrence of a harmful event at a workplace. These events are referred as incidents. Incident is determined as an occurrence arising out of, or in the course of, work that could or does result in injury and ill health. A specific type of incident where an injury actually occurs is sometimes referred as an accident, whereas a near-miss is an incident where no injury occurs. (SFS-ISO 45001:2018)

2.2 Performance

Although the term performance is commonly used, its definition varies depending on the context in which it is spoken. It can refer to performing a play or a piece of music, but in the organizational context, it is often referred as “the measurement object's ability to achieve results in relation to goals” as Lönnqvist (2004, p. 28) defines it. van Dooren et al. (2015, p. 20) defines performance simply by stating that “performances are the outputs and outcomes of activities” but van Dooren et al. adds that the definition does not really tell much about the substantive content of performance, nor does this definition describe the relationship between performance and a goal.

In this thesis, the concept of performance is defined similarly to Lönnqvist (2004, p. 28) in relation to goals. Performance is understood to mean the set of activities, abilities, and outputs and the ratio in which they meet an organization's goals. So not only the end result is taken into account, but performance also includes means and abilities to perform well. In the context of occupational health and safety, performance is referred to as safety performance, which can be considered to be part of organizational performance (Wu et al. 2008). Safety performance influences the organization's performance through, for example, reduced accident costs and improved productivity (Tappura et al. 2015). Safety performance refers to safety events, such as accidents at work or safety behaviors (Hale et al. 2010). Safety performance measurement covers reactive and proactive measurement, the former focusing more on results (e.g., accidents at work and sick leave) and the latter on activities (e.g., safety behaviors).

2.3 Measurement

According to Tarrants (1980, p. 4), the purpose of measurement is “to represent the characteristics of observations by symbols that are related to each other in the same way that the observed objects, events, or properties are related”. Boumans (2007, p. 3) describes measurement in economics as “the assignment of numerals to a property of objects or events according to a rule to generate reliable information about objects or events”. This description highlights one of the central measurement problems: reliability. Hannula and Lönnqvist (2002, p. 53) give a definition of reliability, according to which reliability describes a measure's ability to produce accurate results. However, according to Hannula and Lönnqvist (2002, p. 53), high reliability does not guarantee the validity of a measure to be fulfilled. Validity is another characteristic of a successful measurement. A valid measure produces information that is representative of what is being measured (Tarrants 1980, p. 16). In addition to its reliability and validity, there are many other criteria for a good measure, such as stability and efficiency (Tarrants 1980, pp. 16-20). The requirements for successful performance measurement are covered in the literature review in the sub-chapter 4.4. Indicator selection principles.

Both Tarrants (1980) and Boumans (2007) use terms object and event in their above definitions of measurement. In general, these terms, thus the phenomena that are measured are called measurement objects. Measurement objects can be related, for instance, to the activities, outputs, or outcomes of an organization (Jääskeläinen 2010, p. 9), and they can include either material or immaterial things (Lönnqvist 2004, p. 29). In the context of performance measurement, these measurement objects are often called success factors (Lönnqvist 2004, p. 31).

Measurement is commonly carried out through measures. Lönnqvist (2004, p. 31) defines a measure as “the means for determining the status of an attribute or attributes of a measurement object”. Another definition specifies a measure as “a quantitative value that can be scaled and used for purposes of comparison” (Simons 2000, p. 234). The terms measure and indicator are often used as synonyms (Hannula and Lönnqvist 2002, p. 46). In this study, the specific interest is in measuring safety performance, and in this field, measures are often referred to as indicators. For this reason, the term indicator is also commonly used in this study. Measures can be classified in various ways for the purposes of performance measurement. These performance measurement types are examined more in detail later in this study in sub-chapter 4.1 Process of developing a performance measurement system and in the OHS measurement context in sub-chapter 4.3 Categorization of safety performance indicators.

2.4 Performance measurement

Now that the terms performance and measurement are defined, next a combination of these terms, the concept of performance measurement can be explained. Performance measurement is a significant part of performance management (Fryer et al. 2009). Hannula and Lönnqvist (2002, p. 46) state that there is no single well-known definition for performance management, but according to them, the term emphasizes that measurement is used systematically and actively to manage and develop the performance of different business activities. These business activities may include, for example, decision making, control, signaling, external communication, education, and learning (Simons et al. 2000, p. 67). Table 1 summarizes different definitions of performance measurement in academic literature.

Table 1. *Different definitions of performance measurement in the literature*

Reference	Definition
(Neely et al. 1998, p. 5)	Performance measurement is a process of quantifying the efficiency or effectiveness of a past action.
(Hannula and Lönnqvist 2002, p. 47)	Performance measurement is a process used to determine the status of an attribute relevant to the performance of the measurement object.
(Lemieux-Charles et al. 2003)	Performance measurement is monitoring that shows where change is required, and which will, in turn, produce the desired behavior that will produce improved performance.
(Lönnqvist 2004, p. 31)	Performance measurement is a process used to determine the status of an attribute or attributes of the measurement system.
(Radnor and Barnes 2007)	Performance measurement is quantifying, either quantitatively or qualitatively, the input, output, or level of activity of an event or process.

It can be seen from Table 1 that different descriptions do not vary significantly from their basic elements. While Neely et al. (1998, p. 5) seem to emphasize performance measurement on historical events, Lemieux-Charles et al. (2003) instead highlight its focus on revealing future development needs. Instead, Neely et al. (1998, p. 5), Hannula and Lönnqvist (2002, p. 47), and Lönnqvist (2004, p. 31) all emphasize the process nature of performance measurement in their definitions. Hannula and Lönnqvist (2002, p. 47) describe this process of measurement to consist of different phases, such as selecting appropriate measures, agreeing on measurement principles, setting performance goals,

calculating and reporting the results, taking corrective actions as well as regularly assessing the measures.

In this thesis, performance measurement is defined, similarly to Lönnqvist (2004, p. 31), as a process of determining the statuses of the measurement system's attributes. Also, in this thesis's context, performance measurement relates widely to all quantitative information related to occupational safety. This information includes, for example, lost time incident frequency rate (LTIF), a number of reported hazardous situations, days lost through occupational injury, days lost through illness, safety climate scores, job satisfaction scores, or related cost follow-up.

The performance measures used in the organization together form a performance measurement system. According to the definition of Hannula and Lönnqvist (2004, p. 43), a set of measures necessary for the performance of a measured object is called a performance measurement system. Lönnqvist (2004, p. 33) challenges this definition by pointing out that, in practice, a measurement system often includes irrelevant measures but then again may lack measures that would provide essential information to the organization. This perception is at the core of this study, as it aims to determine which measures should be included in companies' performance measurement system.

2.5 Safety performance measurement

In academic literature, there is no standard definition for OHS or safety performance, but the concept is multidimensional, and the definitions depend on differences in purpose or subject of the research (Liu et al. 2013). Burke et al. (2002) describe safety performance as actions or behaviors that individuals exhibit at work to promote the health and safety of people and the environment. In this thesis, safety performance is used as a synonym for more formal occupational health and safety performance. As described earlier, for the purposes of this study, safety performance measurement is seen as a process of determining the statuses of attributes of the safety measurement system. These attributes can be, for example, individuals' attributes, such as understanding or behavior or organizations' attributes such as management's involvement in safety issues.

Measuring the safety performance is usually considered problematic because measures such as accident rates and compensation costs are reactive in nature, i.e., they only appear after an event, such as an accident. Besides, accidents are relatively rare (Cooper and Phillips 2004). Christian et al. (2009) see safety performance to consist of two related concepts. They make a distinction between measuring safety outcomes, such as the number of workplace injuries per year with tangible measures and measuring

safety-related behaviors, such as wearing protective equipment. Thus, the problematic relation to safety performance measurement that Cooper and Phillips (2004) describe can be seen to be more related to measuring safety outcomes with lagging indicators. When assessing safety performance, other types of indicators are also used: leading indicators are often process focused and measures actions taken to improve health, safety and wellbeing and prevent undesirable events before they occur (ISSA 2020, p.12). International Social Security Association, ISSA (2020, p. 12) distinguishes proactive leading indicators from the leading indicators as a separate level. Proactive leading indicators focus on recognizing, creating, using and evaluating opportunities for continual improvement (ISSA 2020, p.12).

From a safety management viewpoint, information gathered from different measures is needed mainly to decide where to focus the safety-related actions, such as safety interventions (Hale 2009; Bitichi et al. 2011). Information is also used to monitor the level of safety, motivate actions, and link performance to rewards (Hale 2009; Bititci et al. 2011; Cocca and Alberti 2010). According to Zwetsloot et al. (2020) the performance information provided by indicators can be used internally to improve safety, health and wellbeing, towards external business relations and supply chains, and facilitate internal and external benchmarking. Lastly, performance information can be used to develop occupational safety competencies (Tung et al. 2011).

3. MANAGEMENT OF OCCUPATIONAL HEALTH AND SAFETY

3.1 Safety management and safety leadership

Safety management is carried out through an occupational health and safety management system (OHSMS), a safety management system for short. The management system includes various company functions and areas, such as organizational structure, planning activities, responsibilities, processes, and resources (BS 18004:2008). The safety management system is part of the organization's larger management system (BS 18004:2008) and consists of a collection of managerial procedures used to reduce occupational injuries and ill health in the workplace (Frick and Wren 2000). According to Fernández-Muñiz et al. (2007) the development of the safety management system should be considered as a means to create awareness, understanding, motivation and commitment among all the members of an organization.

Hale et al. (2010) explain the safety management system to be influenced by policy, regulation, market, and other societal forces. Safety management system, so plans, procedures, resources, and controls are used to prepare, guide, and optimize individual and group level actions at work. Monitoring and communication in the form of feedback are used to ensure that the safety performance objectives are met. If an accident happens in the level of work processes and methods, it should be noticed through monitoring and that should trigger changes in the safety-related IT-systems and safety management system itself. The loop describing the management of safety is presented in Figure 2.

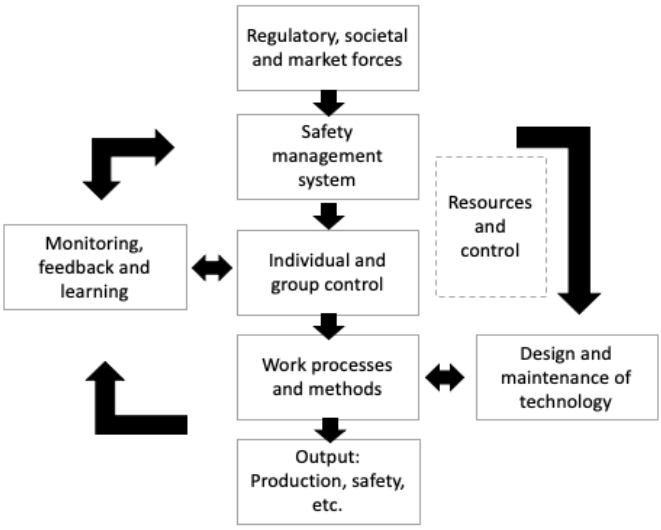


Figure 2. *Safety management framework (adapted from Hale et al. 2010).*

In the literature, management and leadership are traditionally separated due to their distinct processes or roles (Yukl 2010, p. 25). Especially leadership is found to play a crucial role in the way safety is managed in the organizations (Lutchman et al. 2016, p. 74). However, the leadership perspective is not usually emphasized in OHS management literature (Tappura 2017, p. 31). Yukl (2010, p. 26) defines leadership as a process for influencing others to understand and agree on what needs to be done and how to do it. Yukl (2010, p. 26) continues the definition by adding that leadership includes a process to facilitate individual and collective efforts to achieve common goals. Lutchman et al. (2016, pp. 74-75) have identified several roles and responsibilities for leadership to improve safety performance. Lutchman et al. state that the role of leadership is to provide leadership, direction and sufficient resources, establish standards and procedures, define roles and responsibilities, set objectives, establish accountability for performance against objectives and audit the OHS management process.

Two different approaches can be identified to leadership and safety leadership: transactional and transformational style. In a transactional management approach, a manager sets objectives and monitors employee performance relative to them, and rewards or provides corrective feedback on performance. Transformational management encourages employees to commit to goals and shows interest in employees (Zohar 2002). Transformational management can also be described for example by manager being a role model for safety (Lu & Yang 2010) and a constructive dialogue (Hale et al. 2010). In fact, constructive dialogue between the employees and management has been identified as a key factor in successful safety interventions and improved safety performance (Hale et al. 2010). Tappura (2017, p. 96) found in her research that a lack of opportunities for dialogue forms an obstacle for openness in the organization.

Partly the same management and leadership practices, that were linked to transactional and transformational leadership, such as communication, rewarding, management commitment, and employee involvement and collaboration are related to OHS performance in several studies (e.g. Vredenburgh 2002; Mearns et al. 2003; Grabowski et al. 2007; Hale et al. 2010). Lin and Mills (2001) found that employee and management commitment to OHS along with company size are the most important factors that influence safety performance.

Management commitment plays a particularly important role in, for example, collecting occupational health and safety data, behaving as a role model, and supporting occupational health and safety as an important priority throughout the organization (Lingard et al. 2011, Zohar 2010). Tappura (2017, p.98) found that management's overload, production pressure, and role conflicts are the major factors that can weaken management

commitment to OHS. Management's commitment and support for OHS measurement can reflect, for example, in the measurement system implementations and allocation of resources to safety activities (Fernández-Muñiz et al. 2007). It is the management's responsibility to allocate and prioritize the resources required for safety-related tasks (Rundmo and Hale 2003; Gunduz & Laitinen 2017). Resources can also be viewed from another perspective here. Not only do the resources provided by the management facilitate the safety activities of the rest of the organization, but they can also be seen as enabling the work of the manager. In fact, top management's resources, appreciation, support for OHS work and support from colleagues promoted managers' commitment to OHS (Tappura 2017, p. 77). Thus, adequate resources and support should be provided also to managers (Frick 2013).

Management influences the level of employee commitment. According to Fernández-Muñiz et al. (2007), a management system allows employees to involve in the decision-making process, and through this, it also enhances their commitment to the organization and common interests. Also, Tsao et al. 2017 found in their research that management commitment and employee involvement have a remarkable effect on safety awareness and behavior through a safety management system and workgroup processes. Chen et al. (2013) identified leadership behavior overall to be a key factor in developing employee job attitudes and behaviors. What these different models have in common is that they all seem to agree that leadership has a large impact on employee behavior, which in turn is reflected in performance. The chain leading from a leader's characteristics and behavior to employees' job attitudes and behavior is presented in Figure 3.

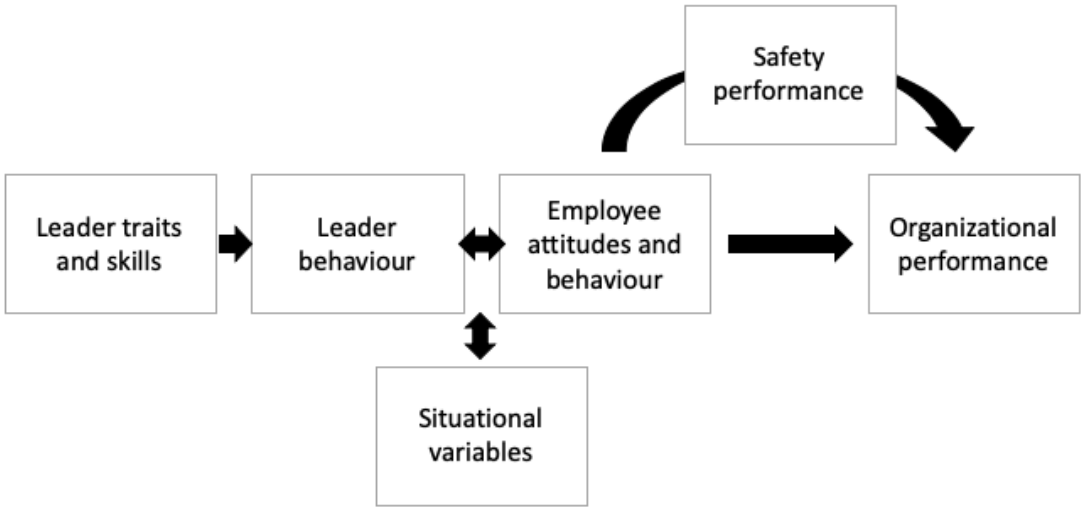


Figure 3. *The impact of leadership on organizational performance (Tappura et al. 2015, modified from Yukl 2010, p. 31.)*

Employee's safety behavior is often divided into safety compliance and safety participation (Neal et al. 2000; Griffin and Curcuruto 2016). Safety compliance can be influenced by a transactional leadership, while transformational leadership impacts safety participation (Bass 1985, as cited in Tappura 2017, p. 44). Safety compliance refers to following safety procedures and safe performance of work, whereas safety participation refers to voluntary participation in safety-related activities including e.g. helping colleagues, showing initiative, and making efforts to improve occupational safety (Neal et al. 2000). Although we are talking here about safe behavior of employees, it is important to note that safe behavior is not limited to them, but each hierarchy level has its common and desirable behaviors that assist in promoting safety (Taylor 2010, p. 22). Figure 3 can be seen to support the assumption: Although management behavior and employee behavior have been described as separate factors, they have been illustrated as interacting. For these reasons, the term individual behavior could be used in this context.

3.2 Safety culture

Management and especially management commitment to OHS are known to have a great impact on a part of the organizational culture that is specifically concerned about safety (Hale et al. 2010). This part is called safety culture. Safety culture can be defined as the combination of attitudes, beliefs, motivations and choices of both the employees and the management in relation to safety (Hale et al. 2010). A safety culture aims to develop a norm in which employees are aware of safety risks and take them into account in the workplace (Ostrom et al. 1993).

Good safety culture is often seen to lead to improved OHS and organizational performance (Hale et al. 2010). Although a safety culture plays a crucial role in performance, the challenge is that its measurement is not straightforward due to its intangible nature. In fact, according to Taylor (2010, p. 129), it is not possible to directly measure safety culture, as it constructs of elements that are incapable of being perceived by the senses, such as beliefs. However, it is recognized that a good organizational culture consists of certain characteristics that can be measured, either quantitatively or qualitatively. Taylor (2010, p. 133) has identified five characteristics, examples of which are "Safety is a clearly recognized value" and "Accountability for safety is clear". Characteristics are measured by using qualities, or safety attributes associated with each characteristic. Through the assessments of these characteristics also the level of safety culture can be indirectly evaluated. (Taylor 2010, p. 133) Ostrom et al. (1993) found in their study that a standardized written questionnaire is a good measurement instrument to be used in

addition to informal employee interviews to gain a more extensive understanding of the safety culture.

The written questionnaires used to measure safety culture often include questions in the categories such as management commitment, communication, employee involvement, reporting and training (Gordon et al. 2007; Tappin et al. 2015), which can also be considered as components of, for example, management or processes as culture alike. This only highlights the complex interconnections between different safety related interventions and activities.

Looking at an organization, Guldenmund (2010) sees the culture to interact with structure and processes to generate the desired level of safety performance. The model in Figure 4 illustrates these three components and their relation to each other as a triangle. Processes refer to core business processes and supporting processes that occur throughout the organization (Guldenmund 2010). Organizational processes may include primary level processes, such as management processes and systems, but processes may also relate to social relationships, communication and exchange of information among individuals in an organization (EU-OSHA 2011). Structure, in turn, refers to formalized prescriptions of how members of an organization relate to each other and complete their work (Neubert et al. 2016).

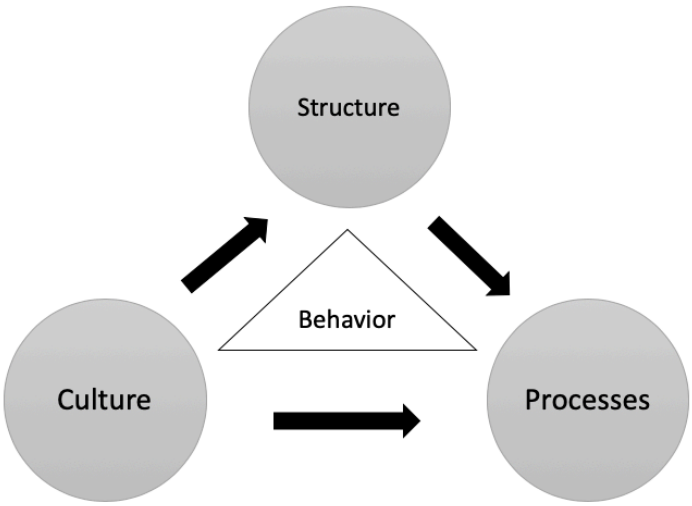


Figure 4. *The organizational interaction to generate the desired level of safety performance (modified from Guldenmund 2010).*

According to Guldenmund (2010) these three aspects together also create a context, where behavior takes place. Also, Taylor (2010, p. 3) sees the elements of safety culture, e.g. beliefs, values and attitudes influence the behavior of individuals in the organization, but he disregards the meaning of structure and processes. Employee's safety behavior, in turn, is known to have a significant role to play in maintaining a safe work environment

and predicting accidents at work (Christian et al. 2009; Neal and Griffin 2006). As previously discussed, another way to describe the relationship is Yukl's (2010) suggestion that a manager's management skills influence the manager's behavior, which in turn influences employees' attitudes and behavior and thus organizational performance.

The safety culture is expressed through the organizational climate (Guldenmund 2000). Safety climate can be defined as a specific form of organizational climate, which describes an individual's perception of the value for safety in the organization (Neal et al. 2000). Neal et al. (2000) found in their study that interventions to improve the safety climate, such as training or emphasizing the importance of safety, are more effective when implemented within a positive overall organizational climate. In general, occupational health and safety has traditionally been addressed through negation, although it would be important to shift to a positive perspective and to recognize "organizational potential for safety" (Reiman and Pietikäinen 2011). According to Reiman and Pietikäinen (2011), there is a need also for positive safety performance indicators that can help in monitoring the positive aspects of the organization and thereby develop the system safety through positivity.

3.3 The economic effects of OHS management

As stated above, safety management and, above all, safety leadership, as well as safety culture or climate, largely affect the safety performance. Wu et al. (2008) describe this relation by stating that two paths affect safety performance. Safety performance can be affected either directly by the leadership, or so that safety leadership first influences the safety climate and safety climate then has an effect on safety performance. This relationship is illustrated in Figure 5.

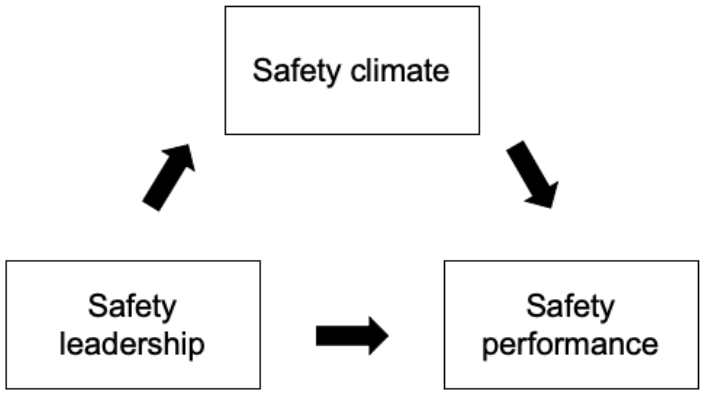


Figure 5. *The relation between safety leadership, safety climate and safety performance (modified from Wu et al. 2008).*

The chain does not end in safety performance, but safety performance has an impact on all the way to an organization's performance, for example through reduced accident costs and improved productivity (Sievänen et al. 2013, Tappura et al. 2015). Especially the management's success is usually measured by the extent to which organizational performance is enhanced (Yukl 2010, p.10). According to some theories, safety performance can be counted as belonging to organizational performance, but in this work, it has been raised to a special position as a separate entity. In addition to safety performance, the organizational performance includes competitiveness performance and economic-financial performance, which both ultimately show up as economic impacts on the company (Fernández-Muñiz et al. 2009). Figure 6 illustrates how investment in occupational health and safety is also justified from an economic point of view.

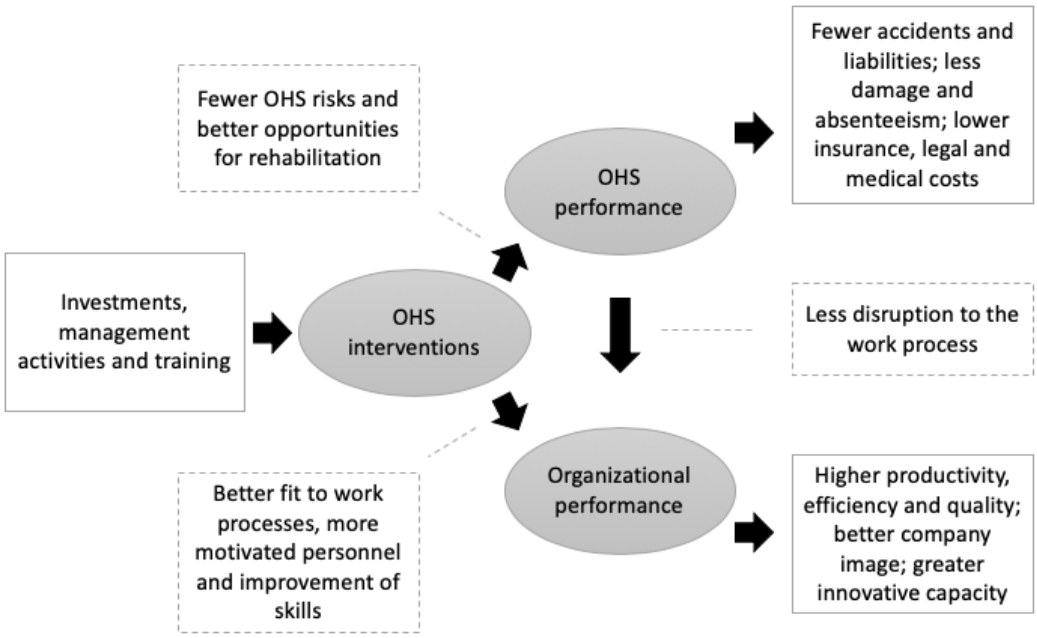


Figure 6. *Economic effects of OHS (adapted and modified from Mossink and De Greef 2002, p. 12).*

Occupational accidents have economic consequences, and thus the enhanced safety performance appears as monetary savings and benefits. Prevention activities and the consequences of accidents both cause costs. Organizations incur preventive costs, for example from developing health and safety management, actions to improve working conditions and carrying out health and safety inspections. (Aaltonen and Söderqvist 1988) Accidents and occupational injuries, on the other hand, can result in, for example, absenteeism costs as well as medical and legal costs (Mossink and De Greef 2002, p. 12).

One way of categorizing organizational costs and benefits of safety is to divide them into direct and indirect. Direct impacts are defined as those impacts that are observable and

easily quantified, such as health and safety personnel time or production downtime (Linhard 2005). In the case of indirect benefits, safety first affects direct factors, such as the production downtime, which in turn can contribute to, for example, improved productivity and quality, which then affect the customers' satisfaction and the company's reputation (Fernández-Muñiz et al. 2009). Other potential indirect benefits from safety include increased better product quality, customer satisfaction (Linhard 2005) and reputation (Fernández-Muñiz et al. 2009; Gavious et al. 2009). Fernández-Muñiz et al. (2009) describe such benefits to belong under the dimension of competitive performance as they are considered key factors for competitive advantage.

As stated earlier, according to Fernández-Muñiz et al. (2009) both competitiveness and economic-financial performance eventually appear as economic impacts. The realization of improvements, such as productivity or customer satisfaction are reflected in money, as they lead to cost savings and a possible increase in the company's market share. These together show an increase in the company's profits and so on its profitability. (Fernández-Muñiz et al. 2009) Table 2 describes some of the potential indirect benefits of safety and their monetary value.

Table 2. *Potential organizational performance benefits from preventive safety activities (adapted from Mossink and De Greef 2002, p. 17).*

Benefit	Description	Monetary value
Increased productivity and other operational effects	Reduced costs for facilities, energy, materials and personnel; increased productivity	Total of cost reduction directly related to intervention to be estimated from effects on the company's operation.
Improved quality of products and services	Changes in product or service quality; reliability of deliveries	Value depends on company strategy. Reduction in repair costs and warranties
Improved well-being, job satisfaction and working climate		Only indirect effects, e.g. on productivity, quality or flexibility. Increased capabilities to deal with unexpected situations
Compensations and subsidies received from insurance or authorities	Support for prevention only, compensations received for sick leave or disability are to be excluded	Compensations and subsidies received
Company image effects	Attractiveness to customers, attractiveness on labour market, attractiveness to contractors	Indirect effects
Impact on non-economic company values	To be derived from mission statements and the like, typically strategic considerations	Indirect, long-term effects

Innovative capacity of the firm	Ability to innovate in products and production processes	Indirect, long-term effects. No operational benefits

Demonstrating the costs and benefits of OHS investments and interventions is widely considered important, as it can, for example, motivate management to take better account of OHS issues and guide decision-making (Sievänen et al. 2013). Although addressing the costs and benefits is known to be important, they are rarely evaluated (Jallon et al. 2011). This can also be seen from Table 3, that summarizes proven and potential organizational impacts of safety. Examples of previous studies on the effects of safety on organizational performance are both hypothetical and empirically verified, but the researches that are based on empirical proven findings are relatively sparse.

Table 3. *Examples of studies concerning the proven and potential organizational benefits of safety.*

Reference	Organizational impact	Proven / Potential
Mossink and De Greef (2002)	Productivity, quality, image, cost, innovation	Potential
Linhard (2005)	Productivity, quality, customer satisfaction	Potential
Veltri et al. (2007)	Quality, productivity	Proven
	Stakeholder satisfaction	Potential
Gavious et al. (2009)	Direct and indirect costs	Proven
	Reputation	Potential
Fernández-Muñiz et al. (2009)	Image, reputation, productivity, innovation, sales, profits, profitability	Proven
Köper et al. (2009)	Quality, productivity, cost reduction, absenteeism	Proven

There might be multiple reasons for the lack of measurements and evaluations proving safety investment effects on organizational performance. Jallon et al. (2011) state that the difficult and time-consuming data collection process constraints the assessments. Tappura et al. (2015) instead argue that the costs of investing in safety are often well-known, but the problem is that the benefits are usually difficult to express in terms of money. According to Zwetsloot et al. (2010), one explanation for the seldomly performed evaluation could be the intangible nature of many benefits. Zwetsloot et al. (2010) argue that intangible benefits, such as a good employer reputation among the possible and current employees, are long-term and complicated to measure. Köper et al. (2009) noted

in their research that the most significant challenges were related to data availability and reliability and validity, as the definitions and formats of data varied in the information systems of the organizations studied. In the case of costs, Gavious et al. (2009) argue that developing reliable evaluations is especially challenging for indirect costs. Probably research is often done in the same way as in a study of Veltri et al. (2007): a survey is used to ask for perceptions of benefits and safety status and combining these results statistically. However, as identified in the research by Veltri et al. (2007), the problem with this type of research is the lack of utilizing actual economic data and information provided by leading indicators.

One shortcoming of the existing research is that few studies specify which perspective of safety is thought to affect the benefits: e.g. management, culture or individual behavior. In their research, Fernández-Muñiz et al. (2009) studied the effect of management on company's performance and Köper et al. (2009) identified the impact of human factors such as stress and individual safety behaviors as well as workplace health promotion processes on perceived benefits. Otherwise, it seems in general that most research only discuss safety at a very general level when evaluating its impact on organizational performance. Accordingly, there would be a need for a comprehensive study of the impact of more detailed factors on organizational performance.

3.4 Synthesis: Framework for OHS management and organizational performance

Based on the theory presented in this chapter, a general, theoretical framework was constructed in a SafePotential project. The framework is created by combining safety-related frameworks presented in the academic literature and covered earlier in this thesis. The framework described in Figure 7 serves as a summary of the literature review on the management of occupational health and safety. The framework also provides background material for the empirical part of the study, as it serves an initial version of the framework, the safety performance map, for describing the key factors affecting safety performance. The framework will be supplemented in the empirical phase of the study by a more detailed description.

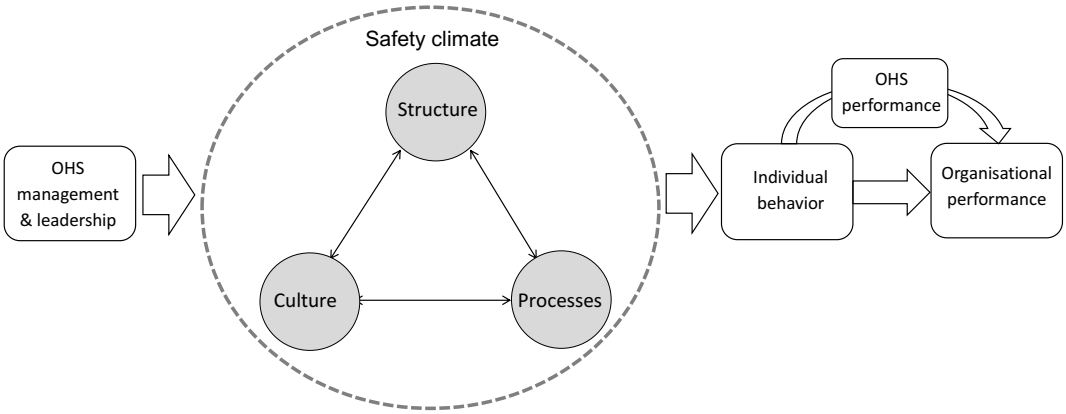


Figure 7. The interaction between OHS management & leadership, organization's structure, culture and processes to generate the desired level of OHS & organizational performance (modified from Guldenmund 2010, Tappura et al. 2015, Wu et al. 2008, Yukl 2010).

The framework explains the chain that leads from OHS management and leadership to OHS performance and eventually is realized as organizational performance. On the right is the end result, i.e. OHS performance and finally organizational performance, and on the left are the things that can be used to influence their formation. In summary, the framework suggests that OHS management and leadership is a prerequisite for achieving excellence in OHS performance. Management and leadership, in turn, affects everything else in an organization: structures, processes, and the formation of a community-wide culture - which together form the safety climate. Both management and leadership (Tappura et al. 2015) and the triad formed by culture, structures, and processes (Guldenmund 2010) influence an individual's behavior. All of this together affects not only the safety performance but also directly and through the safety performance, the performance of the organization (Mossink and De Greef 2002; Wu et al. 2008; Tappura et al. 2015).

4. PERFORMANCE MEASUREMENT

4.1 Process of developing a performance measurement system

Jääskeläinen et al. (2013, p. 25) divides the development of a performance measurement system into five phases (see Figure 8). There is considerable agreement in the literature on the content of the measurement system development project, but the process has been divided in the literature in different ways. For example, Neely et al. (2002, p. 33) propose that the performance measurement process could be divided into four main steps and Bourne et al. (2000) see that the development of performance measurement systems could involve three main stages.

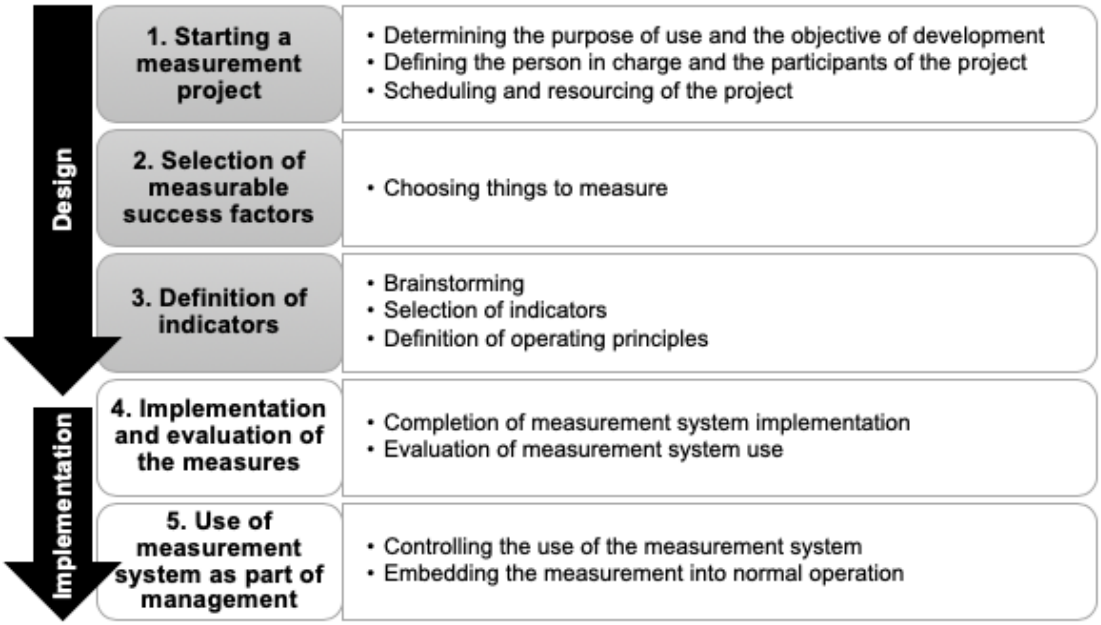


Figure 8. *Measurement system development process (adapted from Jääskeläinen et al. 2013, p. 25).*

Bourne et al. (2000) and Jääskeläinen et al. (2013, p. 25), call the beginning of the process, including the selection of success factors and the selection of measures as the design of the measurement system. This is followed by implementation. This research focuses especially on the first, i.e. the design phase. The design phase is often accomplished in workshops that a facilitator leads, and so is done also in the case of this research. Traditionally in workshops the measurement needs are discussed, and the possible implementation of the system is planned together (Lönnqvist 2004). In this research, however, the measurement project is not carried out only in one organization but in a wider range of companies. This research project is also specific in the sense that

the perception of measurable objects and the mapping of current measurements are done in all surveyed companies, but the assessment of the usefulness of potential new indicators is carried out in only one participating company.

The first task of designing is to identify information needs and consider what are the reasons for the measurement and for the development (Jääskeläinen et al. 2013, p. 26). The need for development may arise from a problem that has been identified in the organization and which solution or determining the causes requires measurement information. Organizational growth, structural changes, general dissatisfaction with the state of measurement or an unstructured picture of the level of measurement can also be reasons for developing a measurement system. (Jääskeläinen et al. 2013, p. 26)

In the second stage of the process, measurable success factors are selected (Jääskeläinen et al. 2013, p. 29). In the context of performance measurement, success factors refer to measurement objects (Hannula and Lönnqvist 2002, p. 56). A strategy map can help select success factors (Jääskeläinen et al. 2013, p. 29). A strategy map is a visualization tool that helps to understand the totality of the things to be measured, and it can be used to consider whether some critical part is missing from the measurement system (Aho 2011, p. 43-44). The strategy map is presented in more detail in the next section 4.2 Visualization of measurement data. This second phase is at the core of this research, as the safety performance map is outlined to provide a general understanding of what are the essential building blocks of safety performance, and thus essential measurement objects.

Once the development objective and the factors to be measured have been chosen, the actual definition of the measures begins. This phase is relevant to the second research question of the study. In the empirical section, the study first identifies the indicators at a broader level than one company, after which the indicators are adjusted to match each identified safety-related success factor.

According to Lönnqvist (2004, pp. 32-33) performance measures can be classified as follows:

- Direct and indirect measures
- Financial and non-financial measures
- Qualitative and quantitative measures
- Subjective and objective measures
- Leading and lagging measures

Conventionally the focus of performance measurement has been on financial information, but recently the measurement of intangible assets has gained more interest (Petty and Guthrie 2000). However, measuring the value of intangible or qualitative elements is often considered difficult (Lönnqvist 2004, p. 23; Tappura et al. 2015). In the context of safety performance measurement, the classification between leading and lagging measures, or indicators as often used when discussed of safety performance, is essential. The traditional focus on safety performance measurement has been on lagging indicators, but there is evidence that the measurement should be shifted towards a preventative focus on leading indicators (e.g. Grabowski et al. 2007, Lingard et al. 2011, Reiman and Pietikäinen 2012; Sheehan et al. 2016) and this aspect also came up in the discussions with the case companies of the research.

The fourth phase is implementation and evaluation of the measures. Finally, after implementation the measures can be used as a part of management and normal operation (Jääskeläinen et al. 2013, p. 34). This means that the measures can be used as a managerial tool, for example, to monitor the progress of business, benchmark to competitors' positions, and to communicate performance to internal and external stakeholders (Neely 1998, p. 71-89). Implementation and usage of measures are excluded from this study, but measures are evaluated as, in the case company presenting food industry, the collected indicators are evaluated in relation to their measurement information needs.

It should be noted that the process will not end in the use of measurement system, but the performance measurement systems requires developing and updating as the situation in the organization or its operational environment changes (Bourne et al. 2000; Jääskeläinen et al. 2013, p. 35). Lönnqvist (2004, p. 104) suggests that in the update phase, the process starts from the beginning and thus the process actually forms a cycle.

4.2 Visualization of measurement data

Visualization refers to representing concepts or datasets either statically or dynamically in a two or more dimensions (Zhang 2012). The use of visualization in management is a somewhat new research area, but the benefits of it have already been identified (Eppler and Bresciani 2013; Al-Kassab et al. 2014). Visualization of performance measures supports management by providing a tool for business decision-making, an information channel, and a means to create new knowledge (Al-Kassab et al. 2014).

There are several ways to categorize visualization techniques. According to Tegarden (1999) visualization can be placed in three different classes: scientific visualization, vir-

tual reality, and data/information visualization. Tegarden describes data/information visualization as the transformation of non-spatial or behavioral data into visual images. Lengler and Eppler (2007) suggest that data visualization and information visualization should be discussed separately. By data visualization they refer to presenting quantitative data in formats such as pie charts, histograms and tables, while information visualization includes for example maps and flow charts. Zhang (2012) argues that the use of visualization in management is mainly limited to the use of statistical charts. Eppler and Bresciani (2013) only partly agree with this statement. They agree that numerical and quantitative charts are most likely to be used, but they have also noticed an increase in the use of qualitative visualizations, such as conceptual diagrams, metaphors and sketches.

Maps serve a particularly advisable visualization technique for visualizing the logic of performance measurement (Banker t al 2004; Jääskeläinen and Roitto 2016). The strategy map enables visualizing how an organization's intangible assets, such as skills and know-how, can be related to the tangible end results, e.g. higher sales. (Kaplan & Norton 2004). That is, strategy maps can be used to illustrate the causal relations between different factors. An example of a strategy map is shown in Figure 9.

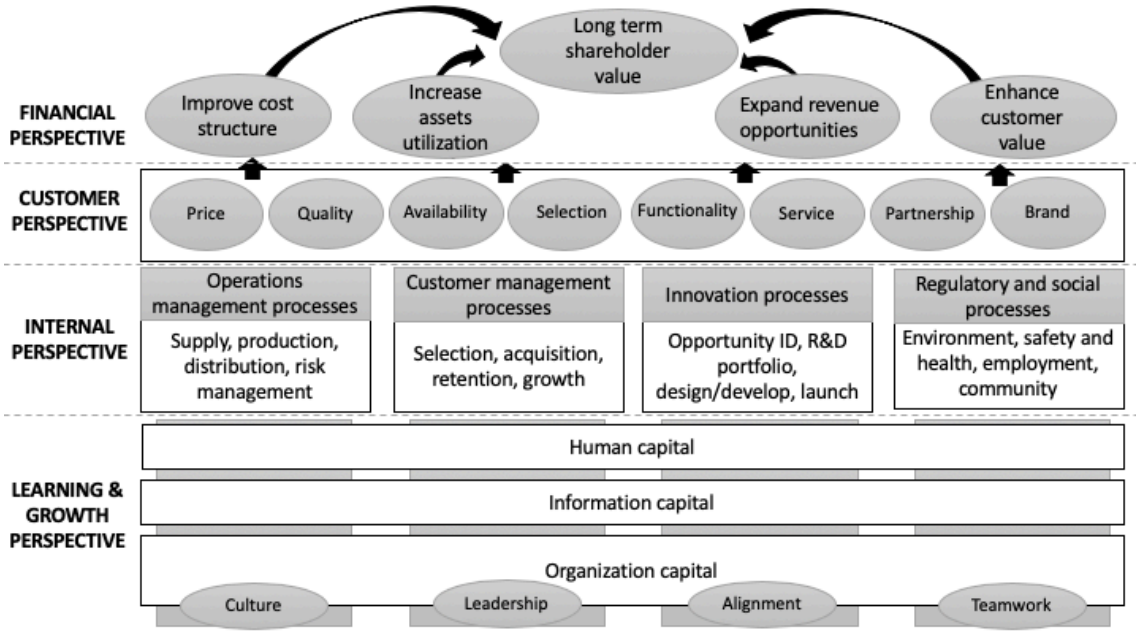


Figure 9. *An example of a strategy map (adapted from Kaplan and Norton 2004).*

A strategy map can be utilized to communicate a company's strategy to the entire organization (Lönnqvist et al. 2006, p. 43-44; Aho 2011, p. 43). Strategy maps also serve as a managerial decision-making tool, by stating the causal relation of different elements and actions. However, to use effectively this tool, training and consistent review of the map is required. (Rompho 2012) A strategy map is particularly useful in serving a simple way

to determine which measures and reports are missing, and which measures are critical and focal to performance (Aho 2011, p. 44).

4.3 Categorization of safety performance indicators

OHS performance evaluation is carried out using indicators (Tremblay and Badri 2018). Reiman and Pietikäinen (2012) define an indicator as any measure, either quantitative or qualitative, that aims at producing information on a topic of interest. Safety indicators instead are measures for items that have been identified as important in the fundamental safety models (Wreathall 2009). Reiman and Pietikäinen (2012) see the safety performance indicators as organizational tools for assessing and improving the sociotechnical activities as a part of the organization's safety management process. They argue that safety indicators can play an important role in providing information on an organization's performance, encouraging people to work to promote safety and increase an organization's safety potential.

Traditionally safety performance indicators are divided into two categories: lagging and leading. Although the terminology used varies, most frameworks seem to be essentially about this duality. Lagging indicators (also referred to as reactive, retrospective, outcome, output or negative indicators) measure the past and focus on reducing workplace injuries. In contrast, leading indicators (also referred to as proactive, predictive, input or positive indicators) measure prevention actions and provide an opportunity to find and resolve safety issues prior to incidents (Sinelnikov et al. 2015, Hinze et al. 2013). The third, and a more recent level in the breakdown of leading and lagging can also be distinguished: proactive leading indicators. International Social Security Association, ISSA (2020, p.12) describe proactive leading indicators to "reflect the actionable, current and ongoing processes, activities and performances that are doing more than merely controlling existing risks and safeguarding the status quo, but focus on recognizing, creating, using and evaluating opportunities for continual improvement".

Reiman and Pietikäinen (2012) go slightly further with their classification. They introduce the division of safety performance indicators into three types: outcome, monitor and drive indicators. Here, two types of leading indicators are distinguished. Leading monitor indicators denote the organization's capacity to operate safely. They are used to monitor the practices, abilities, skills and motivation of individuals of an organization. Leading drive indicators in turn measure the fulfillment of safety management activities made to improve safety and include, for instance, measures for supervisory activity and strategic management. This distinction from Reiman and Pietikäinen is not the only division be-

tween leading indicators. For example, Grabowski et al. (2007) makes a difference between objective and subjective leading indicators and Hinze et al. (2013) argue that leading measures can be either passive or active.

The division between lead and lag indicators has been questioned on several occasions (Swuste et al. 2016). In fact, it is argued that the distinction between leading and lagging indicators is not important at all (Hale 2009; Wreathall 2009). Also, Haas and Yorio (2016) seem to think that a framework that relies on the division between leading and lagging indicators does not provide an adequate overall picture of an organization's safety related activities. The profitability of the division has been criticized, among other things, for the complex and unclear causal chains between lagging and leading indicators and for that the dividing measures in this way does not help to see the complex entity leading to occupational safety in organizations (Haas and Yorio 2016). It has also been argued that the distinction is more complicated as it first appears, as it is possible that a lagging indicator could also serve as a leading indicator, if it would for example be able to predict another outcome or event related to safety (Dyreborg 2009). Despite the criticism presented, a breakdown into leading and lagging indicators is used in this work, because of its prevalence and because no better model for measures division in this context has been presented.

4.4 Indicator selection principles

Conventionally safety performance is evaluated using reactive lagging indicators (Sinelnikov et al. 2015). Many advantages are linked to using lagging indicators. For example, according to Lingard et al. (2011) lagging indicators enable comparing between organizations as they are usually based on a standardized formula. Also, they are found to constitute valid measurements and enable monitoring trends (Lingard et al. 2011) and they can be used to evaluate the effectiveness of preventive actions (Cadieux et al. 2006). However, basing the measurement solely on the reactive indicators is not advisable (Reiman and Pietikäinen 2012). The risk is that if too much value is put on lagging indicators and they are emphasized in the measurement system, employees might learn how to manipulate the results to be favorable, which harms the usefulness of the measures (Lingard et al. 2011). It is also argued in the literature that lagging indicators do not indicate what should be done and which part of the chain should be affected in order to improve accident prevention (Tremblay and Baldri 2018).

Thus, reactive indicators should be supplemented with proactive indicators. However, there are also known problems with proactive measures. For example, the validity of leading indicators is argued to be inconsistent (Sinelnikov et al. 2015) and it is argued

that the information they contain is highly specific (Reiman and Pietikäinen 2012). Reiman and Pietikäinen (2012) also state that using leading indicators is not often simple and the evaluations based on them are generally lengthy and subjective. Despite the drawbacks, leading indicators are in key role in eliminating and predicting harms as they tend to provide early signs of potential failure (Sinelnikov et al. 2015).

As already stated above, the use of reactive and proactive measures should be balanced. This is also due to the fact that they serve slightly different information needs: one means and the other the results. Leading indicators provide a means to track or monitor performance of a process as it is taking place (Hinze et al. 2013), whereas lagging indicators are used to measure outcomes of events that have already taken place (Reiman and Pietikäinen 2012). It has been suggested that the ratio between these two types of indicators should be 80 % or more of leading indicators and 20 % of lagging indicators in a measurement system (Blair and O'Toole 2010). The following Table 4 provides some examples of typical leading and lagging indicators.

Table 4. *Examples of leading and lagging indicators (selected from Koivupalo 2019, p. 67)*

Leading indicators	**Lagging indicators**
Number of near misses	Number of fatalities
Number of hazards	Number of lost time injuries (LTI)
Safety training hours	Number of occupational diseases
H&S audits	Total sick leave hours

Criteria can also be set for the individual indicators selected from these two categories. Many criteria for valid performance measurement and individual measures can be found in the academic literature. Hannula (1999, p. 78) has propounded four requirements for measuring productivity. Even though the criteria are set specifically for productivity measurement purposes, according to Lönnqvist (2004, p. 90), it seems possible to generalize them for wider use in performance measurement. According to Hannula (1999, p. 78) in a sound performance measurement situation, the measurement system and measures would fulfil the requirements presented in the following Table 5.

Table 5. *Requirements for sound performance measurement (Hannula 1999, p. 78).*

Requirement	Definition
Validity	Ability of a measure or a measurement system to measure what it is intended to measure
Reliability	Consistency of the measurement results, e.g. accuracy and precision
Practicality	Cost-effectiveness or the benefit-burden ratio of the measurement
Relevance	Value and usefulness of the measurement results for the users of the measures

According to Laitinen (1989, p. 167) validity, reliability and relevance are the most important criteria for a measure. However, they alone are not enough – practicality of a measure should be considered too. A practical measure is described by three characteristics: economy, convenience, and interpretability. These refer to cost (economy), ease of use of the measure (convenience) and ease of understanding the results produced by a measure (interpretability) (Emory 1985, pp. 100-101). It may not make sense to use a measure that is valid and reliable, if its costs exceed its benefits or it is too difficult to interpret.

Other adjectives set for describing an effective indicator include, for example, sensitive (Hale 2009), specific, measurable, achievable, timebound (OHS best practices 2015; Podgorski 2015), and unbiased (Hale 2009). Bergh et al. (2014), in turn, describe that the indicator should also be quantifiable, as such measures are user-friendly and easy to communicate. However, this requirement has been argued to be problematic, as numerical information does not tell about quality (Swuste et al. 2016). Hinze et al. (2013) argue that qualitative measures should not be avoided, especially if there is no quantitative measure available.

In addition to the criteria set for one measure, requirements can also be set for a set of measures, i.e. the measurement system. According to (Tappura et al. 2010, p. 8) the features set for a good measurement system are balance between short- and long-term and external and internal indicators, consistency with strategy and critical success factors, deriving indicators from higher-level goals and objectives, utilization in day-to-day management, and the continuous development. Meyer (2002, p. 6), in turn, has presented five criteria that the measurement system would ideally meet. These requirements are listed and briefly described below:

1. *Parsimony*. There are relatively few measures to monitor, as having too many measures would mean exceeding cognitive limits and losing information.

2. *Predictive ability*. The non-financial measures serve as leading performance indicators and financial measures as lagging indicators.
3. *Pervasiveness*. The same measures apply everywhere in the organization.
4. *Stability*. The measurement system is stable, in a way that measures would change gradually in order to enable maintaining employees' awareness of long-time objectives and consistency in their behavior.
5. *Applicability to compensation*. People are compensated based on both the financial and non-financial results indicated by the measures.

In addition to Meyer (2002), other researchers also argue that the measurement system should not contain too many measures (see e.g. Neely 1998, p. 50; Jääskeläinen et al. 2013, p. 32). The problem with too many measures is that measuring then comes time-consuming, requires training and preparing people to perform measurements, and a large amount of data to be collected and processed (Podgórski 2015). In addition, the existence of too many sources of performance data may cause an information overload, that can negatively affect management and decision-making (Hwang and Lin 1999). Overall, it is possible that an organization has either too many or too few measures, the used measures are irrelevant, or the measurement results are otherwise difficult to interpret (Neely 1998, p. 42). While the goal of this study is not to comment on what is the right number of measures, the study seeks to help companies in selecting the right measures by pointing out how the different factors affecting safety performance could be measured.

Although, there seems to be a consensus to some extent of the Meyer's (2002) criteria among researchers, some of the requirements could also be criticized. For instance, depending on the context, the criterion of pervasiveness could be disagreed. Sometimes it is important to use different measures to take into account the specificities of organizational units.

4.5 Safety performance indicators in the literature

In the literature focusing on safety performance indicators, there has been surprisingly little emphasis on the presentation of new potential measures. Instead, studies appear to be more focused on, for example, describing and defining the concepts of leading and lagging measures at a more general level (e.g., Reiman and Pietikäinen 2012; Hallowell et al. 2013; OHS best practices 2015; Swuste et al. 2016), discussing safety management and measurement processes (e.g., Hinze et al. 2013; Podgórski 2015; Sinelnikov

et al. 2015) as well as examining the factors affecting safety performance (e.g., Mohammadfam et al. 2017; Sheehan et al. 2016) and associated relationships (e.g., Lingard et al. 2017; Givehchi et al. 2017). Although the main focus of the studies is not on the presentation of indicators, the sources also provide some examples of both lagging and leading indicators.

Similarly to this thesis, some studies have sought to relate indicators with different occupational health and safety perspectives, actions, components, or factors. For example, Mohammadfam et al. (2017) investigated health and safety practices and associated criteria and developed leading key performance indicators for each of the five core OHS practices, that were policy, planning, implementation, checking, and management review. Janackovic et al. (2020) described four factors: technical, human, organizational, and environmental factors, and proposed 48 leading indicators. Also, Podgórski (2015) presents five main components (policy, organizing, OSH MS, planning and implementation, evaluation, and action for improvement) divided further into 20 sub-components and a total of 109 indicators assigned under these headings. Sheehan et al. (2016) identified examples of themes in leading indicators in the literature. The themes listed by Sheehan et al. (2016) include, e.g., accountability for OHS, audits and workplace inspections, consultation and communication about OHS, empowerment and employee involvement, management commitment and leadership, and positive feedback and recognition. However, Sheehan et al. (2016) do not focus on presenting indicators divided under these themes and present only five indicators in their research.

Although several studies do not highlight the distinction between leading and lagging indicators, recently, there has been a growing interest in leading indicators, both in business and literature. The literature covered contained only research concerning either both leading and lagging indicators or only leading measures. None of the studies discussed solely lagging indicators.

In the publication studied, the industries vary from the automotive industry (Köper et al. 2009), construction sector (Hallowell et al. 2013; Hinze et al. 2013; Koivupalo and Reiman 2017) and drilling (Amir-Heidari et al. 2017) to safety-critical industries that are not particularly in the scope of this research, such as nuclear power (Reiman and Pietikäinen 2010) and oil industry (Bergh et al. 2014).

Although the context of the research of Podgórski (2015) does not limit to any specific industry, Podgórski states that the proposed set of indicators in his article should be tailored to specific circumstances of a company, meaning the size, sector, types of occurring hazards, and the company's maturity of OSH management processes. Podgórski

(2015) presents an extensive list of indicators, some of which have been prioritized in the study. According to Podgórski, when choosing the indicators for a company's specific needs, the importance of alternative indicators is emphasized. The perception is interesting, as this research aims to create a generalizable model and a list of indicators in the empirical part of the research, and the study involves case companies from several different fields. This set up is broadly comparable to the multi-industry studies from Hale et al. (2010), Sinelnikov et al. (2015), and Sheehan et al. (2016). Also, a very recent study from Zwetsloot et al. (2020) introduces indicators that are designed to be used across all sectors and despite the size of an organization. However, similarly to the Podgórski's study, this study is not intended to present a list of all the indicators a company should implement, but to provide companies with options to choose from.

A more comprehensive view of the literature described here is presented in a tabular form in Appendix D. The list of studies reviewed in this chapter is not exclusive, as the literature search was not systematic. However, the studies analyzed offer an overview of how the subjects of lagging and leading indicators are recently discussed in the literature and serve as sources for answering the second research question of suitable indicators for measuring different factors affecting safety performance. In addition, the sources studied provide an interesting reference point for the results found in this study.

5. METHODOLOGY AND DATA

5.1 Research methods

Saunders et al. (2009, p. 124) introduce two primary research approaches: induction and deduction. Deductive research builds on a model or theory. Hypotheses are derived from earlier research results and theories, which are then tested with empirical research. Inductive research, in turn, proceeds from the data and seeks to construct new theoretical models. (Saunders et al. 2009, pp. 124-126) This research does not quite fit in one category but instead combines the two approaches introduced. Such approach is called abductive. This study has inductive features as new theory and operating models are developed in the empirical part to get new insights into the theory of safety performance. The new theoretical models, the safety performance maps, are based on the data to be collected during the research workshop phase. On the other hand, the workshops' frameworks and contents are based on earlier literature, so deductive features can also be identified in the work.

Research choices describe the data collection and analyzing procedures chosen for the research. Either one (mono method) or several different (multiple methods) procedures can be used. (Saunders et al. 2009, p. 151) Figure 10 presents the research choices made in this study.

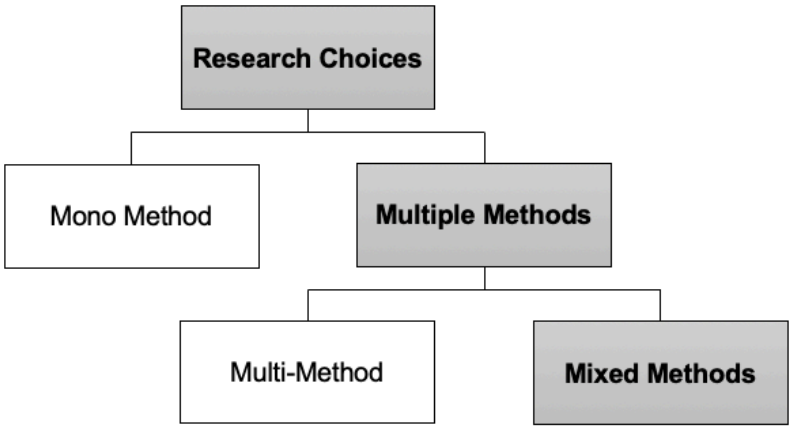


Figure 10. *Research choices of this research (modified from Saunders et al. 2009).*

The research was conducted as a qualitative multiple case study. According to Voss et al. (2002) a case study is particularly a suitable research method for developing a new theory and testing a theory, which both are central for this study. Case studies focus on

the empirical description of a selected phenomenon in a real-world context with the help of various data sources (Yin 2003, pp. 13-14). A case study can be either a single case or a multiple case study. The key descriptive feature of the multiple case approach is a comparison. Multiple cases are studied to understand the similarities and differences between them (Baxter and Jack 2008). The aim may therefore be to find differences between different cases, or the goal may be to find several similar observations in similar contexts and, thus, through repetition, gain credibility for the finding. (Yin 2003, p. 15) The aim of this study is the latter of the alternatives. The study looks for recurring factors and similarities in different case companies to determine the key factors affecting safety performance.

Qualitative data collection methods are typically used to amplify understanding and investigate why and how questions (Saunders et al. 2009, p. 482), such as the research questions of this thesis. In this study, qualitative data is collected through workshops organized with four case companies and with companies participating in the testing phase of the study during the spring. In the testing phase, interviews are organized to validate the created model. Moreover, material from the interviews organized in all the case companies in the earlier phases of the SafePotential project are used in this thesis. In terms of time horizon, the research is cross-sectional where the phenomenon is studied at a particular time. (Saunders et al. 2009 p. 155).

5.2 The case companies

There are four participating case organizations in the SafePotential project. All four Finnish companies involved represent different industries, and their organizational size varies. For data protection reasons, in order to maintain the anonymity of the case companies, the companies will be referred in this study only according to the industrial sector they present.

One of the case companies is specialized in the manufacturing and service of cranes and lifting equipment. From here onwards, the company is referred to as a manufacturing company. The manufacturing company has 18,000 employees in 50 countries at a group level, from which about 1,400 work in Finland. Another participating company is a design, construction, and maintenance company specializing in infrastructure projects, and therefore the company will be referred to as the infrastructure company in this study. In the year 2018, the infrastructure company had approximately 1,400 employees. The third company in the project, referred here as service company, focuses on providing environmental, facility, and industrial support services. With operations in Finland, Sweden, and Russia, the company employs around 8,000 people.

This thesis carries out more comprehensive research in a case organization operating in food industry. The food industry company is a family-owned, international enterprise operating in 13 countries with more than 2,000 employees, and its products are sold in more than 70 countries. In 2019, the company had revenue worth 921 million euros. The food industry company is a leading Northern European coffee and food company known for its high-quality brands and services. The enterprise company consists of four different business areas organized based on the geographical location: Finland & Baltics, Scandinavia & Central Europe, East and Customer Brands, the latest mentioned focusing on customers' own brands. The company has recently renewed its organizational structure and now seeks to harmonize the safety procedures used in different units to create a uniform safety culture. The company is willing to develop particularly preventive safety measurement and find new leading indicators for this purpose.

5.3 Research process

The timeline and the task break-down of this thesis are illustrated in Figure 11. It should be noted that the timeline only describes the thesis project and not the whole of the SafePotential project. Because the thesis is a part of a larger project that started before the writer's contribution, some of the data collection had already been done during autumn 2019. This data collection affects the task order of the research process but is not itself illustrated in the timeline.

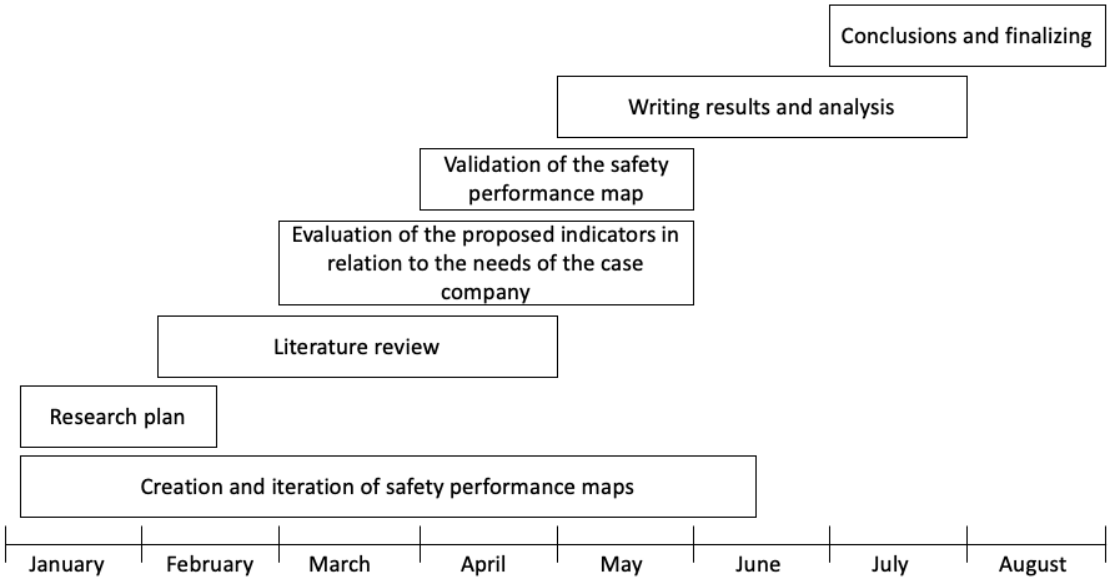


Figure 11. *Timeline of the research process.*

Task 1 - Creation and iteration of the safety performance map

The first task is to create a safety performance map to answer the first of the two research questions. The map is done as a contribution to the SafePotential project, and it is introduced in this thesis. The map identifies the performance dimensions, as well as the building blocks of these dimensions and the relationships between them. The map is based on a more general reference framework previously developed as part of the SafePotential project, which in turn is created based on models presented in the literature on different perspectives of safety performance. The information collected from interviews in all four case companies at an earlier stage of the project will then be used to identify the factors that affect the fulfillment of safety performance and to create a visualization of this – the safety performance map. The map is later iterated based on a workshop, where each case company and will have the opportunity to comment on the first version of the created map.

Task 2 - Validation of the map

The validation of the iterated version is accomplished by testing the model. Testing will be conducted in three new companies through a semi-structured, qualitative group interview method during spring 2020. The purpose is to test the presented relationships between the factors, to evaluate the relevance of the factors involved, and to identify any missing elements. Moreover, the aim is to gain an understanding of industry-specific features.

Task 3 - Linking performance measures to the safety performance map

The map is supplemented by linking the existing safety performance measures used in the four case companies and three companies involved in the testing phase to each of the safety performance perspectives. After that, as a part of literature review, the list of measures is further supplemented with the measures found from the academic literature. This is done to answer the second research question on how the safety performance can be measured in different parts of the chain leading to enhanced safety and organizational performance. The actual literature review is done to help to understand the current academic discussion around the main themes and explain the key concepts and their link to each other.

5.4 Research data collection and analysis

There were several workshops during the research project. The workshops can be categorized into four different groups:

- Two workshops organized separately in all four case organizations to find the factors and relationships contributing to safety performance to create a safety performance map.
- A workshop involving all the case organizations and external safety experts to test the created safety performance map.
- Workshops organized in three new companies to validate the safety performance map.
- Workshops organized with the food industry company, the case company of this thesis, to evaluate the usefulness of the map and the proposed indicators.

Map creation workshops

The first workshops were held in the second half of 2019 before the author joined the research group. The workshops were attended by expert groups, mainly consisting of safety and quality experts of the case companies. In the first workshops, the case companies examined the overall theoretical framework and then had an open discussion of the framework's perspectives. The discussion considered how these perspectives occur in each case company and what sub-dimensions are identified in the companies. Later in the second workshops, the company representatives assessed the order of priority of the perspectives they mentioned in the first workshop and discussed the links between the prioritized aspects. The frame of the workshops can be found in Appendix A of the paper. The workshops were not recorded, but the material was collected by taking notes during the workshop.

The first task in which the author was involved was the analysis of the workshop material. The analysis was made in Excel by coding discussion data from workshops organized in the four case companies. The aim was to find recurring factors or themes in the various discussions to create interpretation and summarize the data. Case organizations were kept separate when analyzing the results. As a more generalizable outcome was sought for the map, there was no desire to emphasize individual observations. For that reason, only if a topic was repeated in discussions with at least two different companies, the factor was included in the safety performance map. The codes used for workshop data classification are shown in Table 6. The factors that occurred only once are also included in the table, but they are struck-through.

Table 6. *Codes used for workshop data classification.*

Perspective	Factor	Food	Manu-facturing	Service	Infra-structure
OHS management	Objectives aligned with strategy		X	X	X
	Sufficient resource allocation	X	X	X	

	Monitoring				
	Rewarding and sanctions	X		X	X
	~~Certified management system~~		X		
	~~Supplier management~~		X		
	~~Lean management philosophy~~		X		
OHS leadership	Management's example	X	X	X	X
	Communication	X	X	X	X
	Transparency		X		X
	Developing awareness and knowledge	X	X	X	X
	~~Coaching~~			X	
	~~Empowerment~~		X		
	~~Safety participation~~	X			
Structure	Flexible structures		X		X
	Clear roles and responsibilities	X	X	X	X
	Line organization responsible	X	X	X	X
	H&S organization supporting line	X	X	X	X
	~~Change management~~				X
	~~Network of experts~~		X		
Safety culture	Safety as a core business value	X	X	X	X
	Commitment and safety in thinking	X	X		X
	Safety as a part of everyday work	X		X	X
	~~Culture of learning~~		X		
	~~Fairness~~		X		
	~~Prioritization of safety~~				X
	~~Harmonization of culture~~				X
	~~The impact of safety culture on reputation~~				X
Processes	Induction and training		X	X	X
	Information systems in reporting		X		X
	Documentation		X	X	
Employees' attitudes and behavior	Employees' attitudes and self-management	X	X	X	X
	Compliance	X	X		X
	Safety awareness and understanding safety reasoning	X		X	X
	Deciding to act safe in pressure and haste	X		X	X
	Caring	X	X		X
OHS performance	Leading indicators	X	X	X	X
	Lagging indicators			X	X
	Development of measurement system	X	X		X
	Performance transparent at all levels	X	X		
	Positivity		X		X
Organizational performance	Quality	X	X	X	X
	Productivity	X	X		

Reputation	X	X	X	X
Cost reduction			X	X
Customer satisfaction	X		X	
~~Business continuity~~				X
~~Well-being is a value~~		X		
~~Less severe incidents~~				X
~~Work overload~~			X	

As a result of the first workshops, was a constructed model based on the data collected from the companies. The new model, the first version of the safety performance map, supplemented the theoretical framework that illustrates the main perspectives by a more detailed description of factors of safety performance.

Map validation workshops

The first version of the map was tested in a workshop with all the four case organizations. The workshop was also attended by two external experts familiar with occupational safety research. The two external safety experts represent the expert panel that consists of six different stakeholder representatives. Experts play a societal role and represent public authorities whose role is to support companies' ability to operate safely. In this study, the experts' role is to comment the map creation especially from the academic perspective, and thus reflect the presented ideas to existing literature on safety management.

In the workshop, the map was considered one perspective at a time in two groups: a group of business representatives and a group of project experts. The interview question used in the workshop are presented in Appendix B. The discussion confirmed many decisions concerning the content of the map, but there were also some suggestions for development and the need to clarify the content. The suggestions and the changes made as well as the outcome of this workshop which is the refined version of the safety performance map are presented in sub-chapter 6.1.3 Iteration of the map based on the validation interviews.

Later the created map was tested with a broader scope of companies. Testing and validation were conducted in three companies operating in different industries during spring 2020. The companies where the testing was performed are presented in Table 7. Testing was carried out using a semi-structured, qualitative (group) interview method. The aim was to test relationships between the factors on the map, assess the relevancy of chosen factors and identify potentially missing factors. In addition, the aim was to gain understanding of the industry-specific features.

Table 7. *The companies involved in the validation of safety performance map*

Industry	**Size** (number of employees)
Forestry	> 20 000
Chemicals	800
Construction	600

Testing started with two opening questions:

- Identify the five (5) most important factors for safety, i.e., the building blocks of safety performance at your company. These are the factors that need to be in place in order to meet your safety requirements. (i.e. basic safety requirements)
- Next, name five (5) safety-related issues that are currently the focus of attention or development in your company, or which you see becoming more important in the future.

Next, the interviewees were asked to place the ten factors they mentioned under the main headings of the more general level framework. This was done to ensure that factors were placed under the correct headings in the original safety performance map. Finally, the interviewees were requested to evaluate the detailed factors of the map section by section. The interviewees were asked to describe with examples how the factors of the map occur in their organizations, evaluate whether some factors are less important or relevant, is anything missing, are the titles informative and are the causal relations on the map rational. The more detailed structure of the workshop is presented in Appendix C.

Workshops in the food industry case organization

Not all topics covered in the interviews of the food industry company were related to the topics of this study, and thus only the sections most relevant to the work were selected for the more detailed analysis. With the food industry company, the same starting workshops were held to create the safety performance map, view the current safety measure, and assess the first version of the map than with the other case organizations as well. Besides, two other workshops were organized. In the first of them, the company's current measurement practices were evaluated using the safety performance map to reveal where the focus of development work should be. In the latter, new measures were proposed for the company.

6. EMPIRICAL RESULTS

6.1 What are the key factors affecting safety performance?

6.1.1 Perceiving map factors through workshop discussions

Examining what are the key factors that affect safety performance is the first research question for this research. Next, the factors identified from the workshop material are examined section by section.

OHS management and leadership

Management commitment seemed to be the common thread in the discussions. However, the theme did not emerge as a single separate factor but was instead linked to various factors under the perspective of management and leadership. The connection between safety and strategy came up in the discussions with the manufacturing company and the service company. The representatives of the service company noted that safety management should have a link to the organization's overall strategy. In discussion with the manufacturing company, it was stated that there are no goals or objectives for safety without a strategy. Overall, the meaning of objectives was identified as crucial in many of the discussions. According to a representative of the manufacturing company, objectives should be fair, achievable, and visible. One person interviewed from the infrastructure company pointed out that it should be clear to everyone what the target level is, i.e., what is wanted and what is actually done to achieve the goals.

When discussing on setting objectives, the importance of monitoring was also often mentioned. Interviewees from the manufacturing company and the infrastructure company found that by setting goals and monitoring their achievement, management can demonstrate a commitment to improving safety performance. For example, an interviewee from the infrastructure company was concerned that everyone in the organization might not be informed about the achievement of their unit's goals. In relation to the achievement of objectives, three out of four companies mentioned rewarding and sanctions in the interviews. Traditionally rewards and sanctions are assessed according to results, and this view came up also in the interviews. On the other hand, the interviewees from the infrastructure company emphasized that they have a need and willingness at the company level to shift rewarding to be more based on active participation in safety actions

rather than the end result, such as accident frequency rate. According to the same interviewees, the problem with performance-based rewarding is that the result may come with luck.

Interviewees from the food industry company highlighted that management also has a role in ensuring that the necessary resources are available to perform the required activities, such as inspections and development work. In general, the interviewees believed that resourcing, the designation of persons and responsibilities relevant to safety, is critical. Resources were also seen to have a link to the strategy. According to one comment in the interview with the service company, even if safety were included in the strategy, there would be no results if no additional resources were allocated to execute safety-related actions. On the contrary, however, this works; even if a safety requirement is not enshrined in the strategy, but management is committed to safety and allocates resources to it, results are produced.

Also, management's example was linked to management commitment for safety, and the theme of leading by example was emphasized in discussions with all companies. In the workshop with the manufacturing company, it was pointed out:

“Commitment is reflected in what is done in practice: You have to make it stand out, be involved in the investigation and show genuine caring.”

Another statement from the manufacturing company summarizes the importance of management's example by stating that:

“It is pointless to expect people to follow instructions if the supervisors themselves do not follow them.”

One crucial aspect of leading by example was seen to be the safety observations by managers or supervisors. Leading by example was thus seen to happen through actions, but also the importance of discussions to motivate employees' commitment to safety was emphasized. According to the interviews, communication should be two-way, and feedback should also be obtained by other means than formally. The concept of transparency was often associated with the communication. On the other hand, transparency was also seen to be linked to objectives, as according to an interview commentary from the manufacturing company, *“if there are no clear objectives, transparency will not be fulfilled”.* In the discussions, transparency was referred to as openness. This includes, for example, the transparent reporting, information, and communication of accidents. It was noted in an interview with the infrastructure company that management commitment is linked to the communication: If the entire management is not committed, the communication chain may break, and the message will not move.

In all four interviews, understanding, knowledge, or competencies were mentioned at some level, but they were discussed from slightly different perspectives. Topics were discussed, for example, from a learning perspective. According to one comment of the manufacturing company, in building safety comes first thinking, then responsibility, action, and finally, learning. Through communication and transparency, the dissemination of information, and thus learning can be enhanced. In all of the companies the discussions revealed similarly that individuals should have an overall picture and a basic understanding of what OHS is. In addition, the food industry company's interviewees pointed out that employees should know how H&S affects the company and what are the legal requirements. The manufacturing company also emphasized the latter aspect. Thus, according to the all interviews, high competence in OHS is not needed, but awareness of safety-related issues is required.

Structure, culture and processes

In the context of management, resources were talked about in terms of management having responsibility for deciding resources. However, resources were seen to be possibly related to several perspectives in the model but clearly linked to OHS structures. In the context of structure, resources were discussed from the perspective of resource allocation and division of responsibilities. It was seen as a matter of organizational structures that everyone in the organization understands one's role and responsibilities in relation to safety. In general, in all of the case companies, safety was seen to be the responsibility of line organizations. Similarly, in all case companies, the task of the H&S (health and safety) organization is to play a more supportive role: develop and plan safety actions, and support supervisors in their safety activities.

Although some companies, mostly the manufacturing company and the food industry company, sought to harmonize safety-related practices, they also recognized and emphasized that harmonization could not always be required if, for example, different operation areas of the same company differed significantly. In such a situation, for example, there may be different local statutory requirements, and therefore safety-related structures should be flexible. Also, a representative of the infrastructure company pointed out that they have a different organizational structure in all business operations, which means that there is no uniform model for executing safety practices.

Also, culture was seen to be built locally in some respects. The infrastructure company interviewee noted that their company has activities across the country in which different professional groups are involved, and the culture may vary significantly between these groups. Also, culture is known to change slowly, so the challenge is how to get the culture

to change throughout a large organization. Accordingly, in all case companies, safety was associated with company values. An interviewee from the food industry company emphasized that safety should be a core value for the entire organization by commenting the following:

“Business values should be reflecting safety: safety is one of the values, more embedded in the core of the business.”

Commitment became apparent earlier in the discussions of management and leadership. In that context, however, there was talk of management commitment, which can manifest itself in many ways in safety-related activities. Even if the starting point is the commitment of the management, the commitment should be a thing common to all members of the organization, and thus part of organizational culture.

As already mentioned earlier, according to a representative of the manufacturing company, when thinking and responsibility for safety are in order, next comes action. Safety is perceived to be an active action. Thus, safety must not only remain at the level of thought or speech, but also much concrete action must be done to achieve safety in the organization. Three out of four interviews revealed that safety is seen to be part of everyday work. For example, a service company representative commented:

“Understanding that safety is not a separate issue, but part of a job well done.”

The processes in the Guldenmund's (2010) model are also related to active doing, as the processes refer to patterns of activity taking place throughout an organization at the operational, tactical, and strategic levels. According to the interviews with the manufacturing company and the service company, safety is above all part of other management processes. According to one of the manufacturing company’s interviewee, a management system means that certain things are agreed upon together; for instance, risk assessment and induction are described as part of this management system. However, there is a long list of processes related explicitly to OHS management. Of these, the reporting process, risk management process, legal requirements, observations, safety briefings, safety walks, risk assessments, workplace surveys, and fire and rescue operations were mentioned in the interviews. So, above all, proactive measures and actions were repeated in the discussions about processes. Of the individual processes, training and induction emerged most often, three out of four times, and were described as essential processes, and they were thus included in the safety performance map.

Based on the interviews regarding the safety-related processes, other topics most often covered in the interviews could be grouped into two more distinctive, but closely related themes: information systems in reporting and documentation. The documentation was

considered to be the result of reporting, and thus the factors were placed on the map consecutively. According to one interviewee, as the factors described in the interview are part of an ongoing process, they cannot, therefore, be put in order. This was also identified in the project research team, and therefore the individual factors are not otherwise related to each other by causal relationships.

Employees' attitudes and behavior

One of the themes in the interviews was employee attitudes and self-management. Employees' attitudes towards work were felt to some extent form a basis for safety and the attitudes towards work were measured in the food industry company, at least. An interviewee from the service company mentioned that also professional pride and employee self-esteem are the starting points for safe behavior. However, according to the same interviewee, professional pride can also be negatively reflected in the fact that it is difficult for an employee to receive or discuss safety-related instructions. Instead, according to the interviewees, self-management is visible in everyday life, for example, in such a way that the given safety instructions are followed to the end and when no one monitors the compliance. The underlying fundamentals could thus be seen to be employee self-esteem and self-management.

The premise is also that individuals follow the rules, even if they do not fully understand why. When an individual understands why certain activities are done to improve occupational safety, the next level of safety maturity is achieved. In this case, awareness and knowledge about why safety is important increase, and, according to the interviews with the food industry, service, and infrastructure companies, the willingness of individuals to take measures to promote safety thus also increases.

The contradiction between urgency and safety emerged in three different interviews. There may be, for example, schedule pressures behind the rush. Therefore, an employee might be to choose between fines imposed by the customer and safe work. An infrastructure company interviewee stated that although fines can also be imposed for not using protective equipment, these fines are in a completely different size range from fines for the delay. Maturity is indicated by the fact that employees work under safety instructions, even when the work schedule is tight.

In two out of four interviews the theme of caring was mentioned. Safety is about caring for each other and taking responsibility for the safety of oneself and others. Caring can be expressed e.g. by intervening when seeing an unsafe act and by giving feedback. One of the interviewees from the manufacturing company commented:

“Safety is an action: when something is seen, it is addressed or driven forward. Safety should be addressed without fear of consequences.”

Caring can also focus on things. According to the interviews of the manufacturing company, care should be taken, for example, to take immediate corrective action and thus prioritize safety.

OHS performance

Each case company mentioned proactive measures and indicators in the interviews. The quantity and quality of proactive activities were considered necessary, and there was a desire to invest in them in the future. Also, lagging indicators were mentioned but were not discussed as significantly. Because these two factors are key factors used to measure how successfully an organization is performing regarding occupational health and safety, they are included in the map.

The term positivity was repeated in several interviews. Safety is traditionally associated with negative factors, such as accidents and incidents, but according to the case companies, safety should be approached through positivity. Typically, negative events are measured in companies, but also, positive events should be emphasized. This can be seen as part of the measurement system’s development, as comments from the manufacturing and the infrastructure companies suggest that in the future, the positivity aspect should also be acknowledged in measurement. The theme of developing the measurement system was also repeated through other aspects of the interviews. In addition to positive measurement, the development of leading measurement, implementation measurement, and daily performance, such as measuring the use of protective equipment, was also mentioned in the interviews.

The factor ‘Performance transparent at all levels’ was also attached to the development of measurement system as well as positivity. However, it was, to some extent, the interpretation of the project research team rather than a data-driven causal relationship.

Organizational performance

Regarding organizational performance, five topics were highlighted in the interviews: quality, productivity, reputation, cost reduction, and customer satisfaction. The factors listed do not necessarily actually affect the safety performance, but the organizational performance is rather a result as described in the original more general level framework. Thus, the factors under other perspectives, together with the safety performance, ultimately affect these five aspects of organizational performance.

In two of the four interviews, costs were discussed, and they were explicitly talked from the cost reduction perspective. The costs were seen to come from both well and poorly done work. The realization of safety was seen to result in a reduction in accident costs. This can be directly reflected in, for example, insurance premiums and replacement costs. On the other hand, at least at the food industry company, measuring organizational effects was considered challenging.

Safety was described as being part of quality. Through safety, a culture of caring and intervention can emerge, in which case the occurrence of mistakes is addressed in a timely manner. This can also be reflected in the quality. In the interviews with the food industry company and the manufacturing company, safety was seen to relate also to productivity. According to the manufacturing company, productivity can occur in the workplace, for example, so that when there are no accidents, everyone is at work as they should, and production or work is not slowed down.

The reputational impact was also identified in all of the interviews. Safety can affect reputation, for example, so that customers will not choose a company with many accidents. Also, investors compare the results of safety indicators. Reputation also has an impact on how attractive employees see a company, and on the other hand, getting talented and motivated employees contributes to quality and productivity and further to customer satisfaction and cost savings, among other things. According to the interview with the food industry company, reputation can also impact customer satisfaction, for instance, through sustainability issues. Reputation and customer satisfaction were eventually linked to the company's business results.

6.1.2 The initial version of the safety performance map

The map was built mainly based on data, in accordance with the factors presented in the previous subsection. However, some researcher-driven changes were made, and for example, some factors were redistributed. This change mainly concerned the factors raised under the heading OHS performance. As the previous sub-chapter revealed, several different factors were mentioned when discussing the factors belonging under the perspective of OHS performance. However, later in a meeting with the project researchers, it was noted that the OHS performance is ultimately about the level of realization of safety and measuring this with leading and lagging indicators. Thus, the perspective of OHS performance was simplified to consist only of the factors of leading indicators and lagging indicators. The other factors mentioned at the same workshop discussions of OHS performance, so development of measurement system, positivity, and performance trans-

parent at all levels were repositioned on the map to be part of processes. All of the mentioned factors were seen to be associated with development, which is commonly acknowledge as a process.

Also, the OHS management and leadership themes that were combined in the previous more general framework were distinguished here, and the themes suitable for these areas were divided. This was justified, as some of the interviewees naturally spoke about these two different themes, and the division has long been identified in the literature. In accordance with the identified division, issues related to *the management of things* were placed under the heading of management and issues related to *leading people* under the leadership theme.

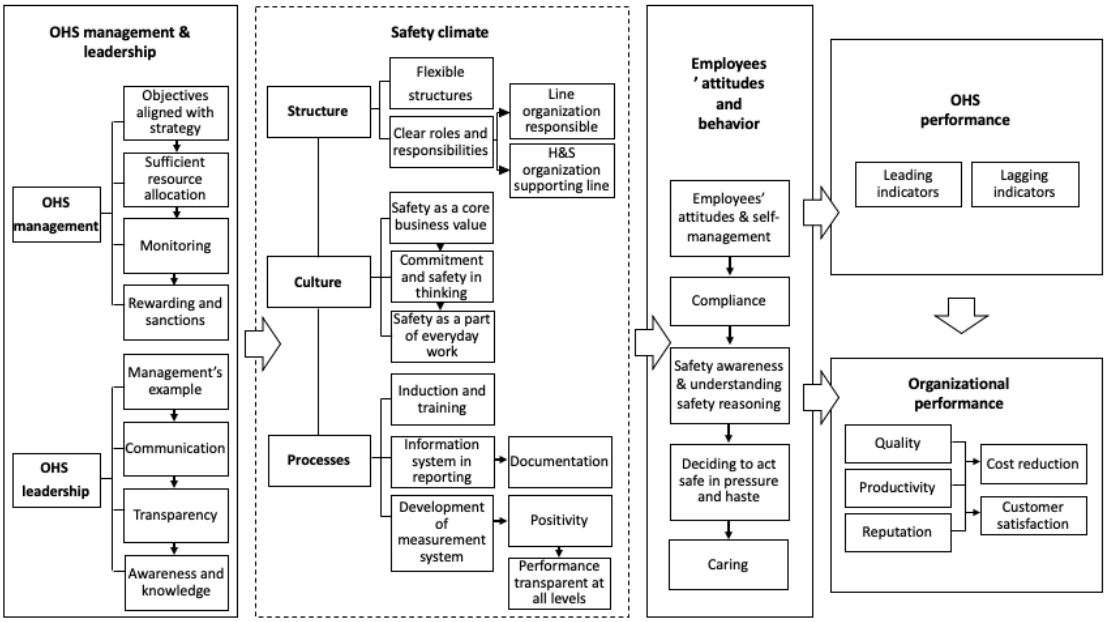


Figure 12. *The first version of the safety performance map.*

In the workshops, the interviewees were asked to prioritize the identified building blocks of safety performance and search for linkages between the factors within one perspective. Especially the factors of induction, communication, clear responsibilities and safety as part of everyday work were emphasized, but none of the prioritized factors were explicitly left out of the first version of the map so that a factor could not be considered to be included under any broader concept.

Interviewees found causal relationships between some of the factors. These relations are indicated in the previous sub-chapter 6.1.1 Perceiving map factors through workshop discussions. However, not very clear nor many links were found in the discussions. Also, the subject did not gain much attention in the interviews. Because of this, the research

team primarily outlined the first model of how different factors could relate to each other. The relations were determined based on the literature and general knowledge. In the OHS management and leadership, employees 'attitudes and behavior, and organizational performance perspectives, the relationships between the factors were quite explicit. These causal relationships may also, to some extent, represent a level of maturity, as is the case, for example, with the factors below the title Employees 'attitudes and behavior. The credibility and correctness of these relationships were validated later in the testing phase of the map.

6.1.3 Iteration of the map based on the validation interviews

The first evaluation of the map was carried out with the experts' panel and the participating companies involved in the creation of the map. For the most part, the commenting was approving, but some changes were also made to the map based on the interviews.

Based on the discussion of business representatives, following factors were added to the map:

- Action plan (OHS management)
- Standards and regulation (Processes)
- Supplier contract management (Processes)

In the group of business representatives, it was felt that annual planning plays a significant role in the management, and it does not yet appear on the map. There was a consensus in the discussion that logically the objectives would be followed by action planning, followed by the definition of adequate resources. The group of business representatives also identified the need to add a factor 'Standards and regulation' to the map under the heading Processes. Standards and regulation were felt to be essential and to form a starting point for processes. The third factor added based on the discussion with the case organizations' representatives is supplier contract management. Supplier management was already mentioned for the first time in the map creation workshops, but only by a one company. Now all the case companies agreed the factor should be on the map. The issue was considered essential and universal, as at least all the companies involved have subcontractors, contractors, or suppliers. Even more broadly, this could refer to all external actors and the process of their contract management.

The expert group pointed out that the map also lacks empowerment and accountability. Empowerment is about involving employees in decision-making and giving them independence so that individuals can use their awareness and knowledge for the benefit of the community. Empowerment was first mentioned by one participating company in the

early stages of map creation. In fact, coaching and safety participation, factors closely related to empowerment were also mentioned in the first workshops aiming at finding the key indicators for the safety performance map. However, at that point, the significance of the factors was not highlighted. Now, it was more evident that empowerment could be an essential factor for safety performance. The project researchers decided to add empowerment to the map and examine in the actual testing phase, whether this factor would be confirmed by the new companies involved in the testing. Accountability instead was not earlier clearly brought up in the empirical material. The research team wondered whether the factor was included in some other factor under the perspectives of OHS management and leadership, for example in monitoring or transparency, to which it could sometimes be seen to be related. Regardless, it was decided not to add accountability to the map at this point without further research.

Also, some of the titles were refined to make them more informative. The title of the main perspective of Employees' attitudes and behavior was changed to the form of Individual behavior. This was done as both the terms 'attitude' and 'employee' were criticized. The term attitude was criticized in both interview groups. Business representatives commented that they try to avoid using the word, and the panel of experts thinks the term is problematic because the structures of a workplace determine what an individual can do. Instead, only experts criticized the word employee and suggested the term individual instead, which would also cover employees in a supervisory position, thus emphasizing everyone's commitment to safety.

The factors 'Commitment and safety in thinking', and 'Safety awareness and understanding safety reasoning' actually contain two different factors, which was found to be problematic. Therefore, the factors were broken into following separate factors, that more specifically represent only one individual theme: safety awareness, understanding safety reasoning, commitment and safety in thinking. At the same time, these new separated factors were placed in places they better fit. The iterated version of the safety performance map is presented in Figure 14. Factors edited or added to the map are marked with a grey background.

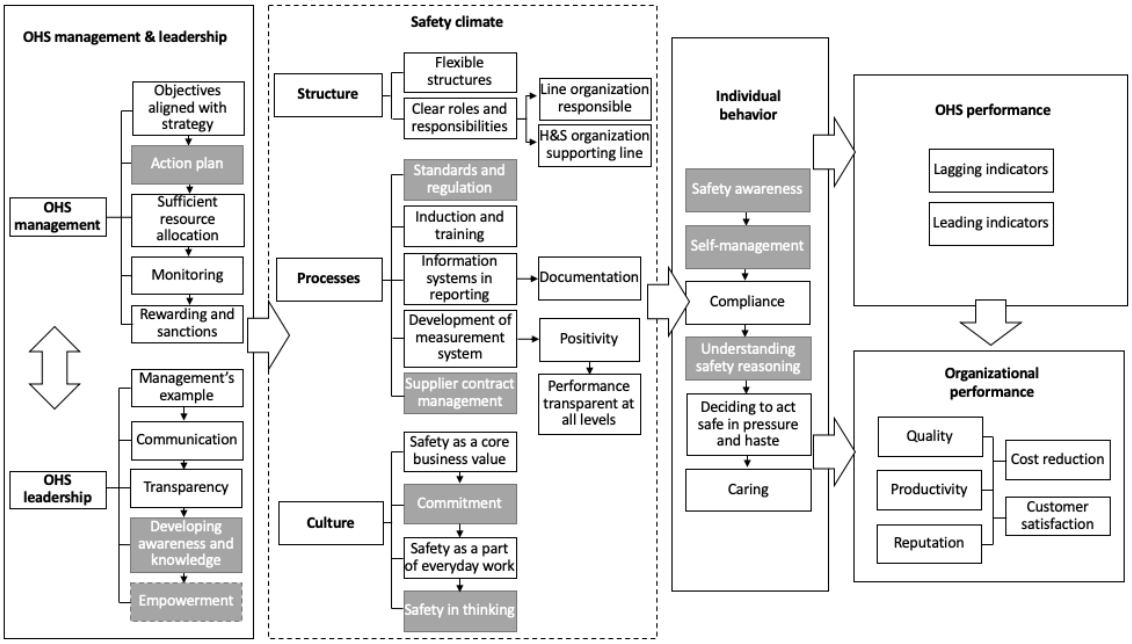


Figure 13. *The safety performance map iterated based on the comments of the case organizations.*

The second iteration was done based on the testing phase interviews. Before presenting the detailed map to the testing group, participants were asked to name the five most important factors for safety, i.e., the building blocks of safety performance at their company and next name five safety-related issues they see to become more critical in the future. This was done to reveal if the same factors included in the map would also appear here, thus indicating the relevancy of the factors involved. The second purpose of these questions was to tell about the maturity of the safety performance and, thus, the mutual order of the different factors. Table 8 presents the answers for both of the questions. The new factors that that were not included in the previous version of the map are in bold in the table.

Table 8. *The factors mentioned in the testing phase interviews.*

Perspective	Basic safety requirements (i.e. building blocks)	Factors of interest in the future
OHS management and leadership	- **Management commitment** and example - Management work - **Empowerment** - Positive communication - Top management commitment	- Information sharing - Human factors - Management's awareness - Empowerment
Structure	- **Common operations models to key issues**	
Processes	- Supplier involvement - Learning about events and high-quality investigation of events - Occupational health and safety plan and planning	- Supplier management and involvement - Accident and near-miss investigation and learning from them

	- Safety training - **Risk assessment** - Comprehensive risk assessment	- Workplace survey - Targeting training - Training (e-learning) - Broader risk assessment perspective - Harmonization of practices - Audits and their harmonization - **Consideration of process and machine safety** - **Deployment and testing of new technologies**
Culture	- Safety must be a value	- Developing leadership and culture
Individual behavior	- Making safety observations	- **Driving forward and increasing the number of safety actions**

The hypothesis was that the answers of the first and second question would differ. However, this was not the case. The answers to both questions were very similar, and the factors could easily be placed under some common heading. The deduction was, that the same topics repeatedly interest the organizations, but with slightly different emphases. For example, safety training was mentioned in the answers to both questions. However, in the case of the first question, it was discussed at a more general level, while in the case of the second question, the answer was given in more detail, for example, the development of online training and the goal of targeting training. Thus, the same themes seem to be specified according to some interesting, trendy, or otherwise topical perspective. This finding supports the existence of the map, because on this basis, it can be assumed that the factors on the map are very fundamental to safety performance and not time dependent.

The new factors that emerged from the first two questions that were not included in the previous version of the map were: management commitment, empowerment, harmonization (common operations models to key issues), risk assessment, deployment and testing of new technologies, consideration of process and machine safety, and driving forward and increasing the number of safety actions. During the testing phase, management commitment emerged as a separate factor. However, the project team found that it is vital that commitment comes up in the culture section, and thus reflects the commitment of members of the entire organization.

Empowerment is a factor that the research team added to the map in the previous iteration phase. In this testing phase, empowerment or the term involving emerged in the answers to both the first and second questions and was thus received confirmation. Later in one of the interviews, a forestry industry company representative claimed the empowerment to be one of the most important factors to be in place and added:

“I don't think a large number of observations automatically create a safe environment, but people at different organizational levels need to be activated and involved. When the employees are allowed to comment on things, they will take ownership of the safety issues.”

As stated earlier in the case of structure, there was talk not only of flexible structures but also of the need for some degree of harmonization. During the testing phase, it was considered that it depends on the situation of the company (for example, the recent organizational change or a company operating globally) or the industry, whether the organization needs harmonization or flexibility. Based on the interviews, flexible structures seem to be particularly relevant for companies engaged in project activities, such as the construction industry. Since the map was intended to be universally valid, the term ‘flexible structures’ was replaced by ‘practical structures’ to refer to OHS structures appropriate to each company's situation and needs.

Risk assessment was identified essential both in the first questions and later in a more detailed examination of the sections. Of the fundamental processes in general, certain integrated processes, such as risk assessment, audit, and accident investigation at the organization-wide level, were seen as missing from the map.

The testing and introduction of new safety-enhancing technologies were mentioned as a completely new factor in the interviews. The construction company stated the new technologies to be in their interest at the moment, and the importance of technology was seen to continue to grow in the future. However, since this aspect of development is a rather individual object of development, just like the development of measurement system already mentioned in the map, it was decided to simplify the map and replace the factor ´development of measurement system’ by the term ‘development’. Thus, this one factor covers various development targets, such as the development of measurement systems, new technologies, development of practices and safety training, development of positive measurement, and visible performance at all levels and for all.

The development of process and machine safety was also mentioned in one of the interviews, but it is considered to be outside the scope of this study due to the safety definition chosen. Instead, the factor ‘driving forward and increasing the number of safety actions’ was included in the map. It was interpreted to refer specifically to individuals' behavior and the participation of personnel, which is a counterweight to the empowerment associated with OHS leadership. In the interview, this ‘I participate’ was referred to as involvement, but the research team decided the term ‘participation’ was more informative. *Participation* is a form of caring about safety *matters*, while *caring* refers above all to caring

about other *people*, manifested in, for example, daring to intervene in another person's unsafe work. Caring, therefore, presents a higher level of maturity.

In addition to the factors mentioned earlier, some other factors were added to the map as well. For instance, a performance discussion was added under the heading OHS management. At the initial workshops this matter was brought up by representatives of the manufacturing company, but it did not gain more attention at that point. Now when the map was discussed one perspective at a time this aspect emerged again. It was found that there was no complete agreement on sanctions and rewards, and in particular, the direct transition from monitoring to sanctions was not considered to be in line with corporate practices. The interviews revealed that, especially before taking punitive action, there should be a discussion that can be used to determine whether the accident was due to the employee's negligent actions or, for example, the lack of adequate instructions or the right kind of work equipment. One of the interviewees of the forestry industry company described the meaning of a performance discussion as follows:

“The purpose is to have a discussion between the employee and the supervisor about how the behavior contributed to the accident. First, through the positive, followed by sparring and coaching, and only if needed, the discipline will follow.”

Fairness that was added under the heading of culture also speaks of positivity and justice. In fact, the phenomenon became apparent at an earlier stage in the creation of the map, where the manufacturing company mentioned fairness as well as equal treatment of people in the interview. At that time, however, this fact was not yet further confirmed, but now fairness was raised as one of the factors of culture. Now the forestry industry company's representative commented:

“We want to create a 'Blame free environment', where everyone is treated the same.”

The factor ‘Standards and regulation’ was replaced by the factor ‘Internal rules’ by the research group's decision. The researchers considered standards and regulation to refer mainly to the legal level of directions. However, in reality, a company can only comply with the legal level or go even further to promote and measure safety. The term supplier contract management under the perspective of processes was also corrected as it was felt to be too narrow. The term ‘contract’ was omitted from the description, and the factor thus changed to supplier management, which covers a broader description.

The last changes were made to the map's performance perspectives. As the OHS performance section of the map was quite unambiguous and did not provoke commenting, the project research group considered its significance for the visualization. Among the researchers of the project, it was concluded that its presence on the map is unnecessary

precisely because of its unambiguity, but also because the whole map describes the factors contributing to OHS performance, therefore it is the end result of the whole map. Also, for this thesis, the factors of leading and lagging indicators under the OHS performance perspective would be opened further when answering for the second research question. Thus, the perspective was removed from the map. A supportive argument for the removal was also that safety performance in some theories is included in organizational performance (Fernández-Muñiz et al. 2009). Therefore, the organizational performance perspective was renamed performance, and safety was added below this.

In a one testing phase interview it was believed that sustainability is a common value for all companies and especially emphasized in today's society. The interviewees proposed that sustainability has an effect on company's reputation. The research team felt the comment was valid, but with regard to occupational safety, in particular, one attribute of sustainability - social responsibility - should perhaps be emphasized. Therefore, social sustainability that refers to promoting wellbeing was added under the new perspective of performance.

Simultaneously, the term 'Cost reduction' was changed to a broader concept of cost management, and 'Customer satisfaction' was fine-tuned according to the following comment of test phase interviewee from the forestry industry company:

"Customer satisfaction, yes, but in a listed company, more of stakeholder satisfaction. More broadly, for example, the owners must be satisfied."

The order of the factors in the individual behavior perspective raised a lot of commentary and wonder, so it was decided to clarify the description of the factors and reconsider their order. In the interviews in the test phase, compliance was perceived as the "most negative" of the factors and therefore perceived to be the first. Safety awareness, on the other hand, was perceived to mean the same as understanding safety reasoning. For this reason, safety awareness was specified to mean the necessary awareness of dangers at the workplace and awareness of the existence of safety procedures, which justifies its place as the first factor on the list. The locations of compliance and self-management factors on the map were also reversed.

The iterated version of the map is visualized in the following sub-chapter, where the final version of the safety performance map is presented and explained.

6.1.4 The final version of the safety performance map

The final version of the safety performance map is presented in Figure 15. The map is here reviewed section by section and all the factors identified to affect the safety performance are explained in detail.

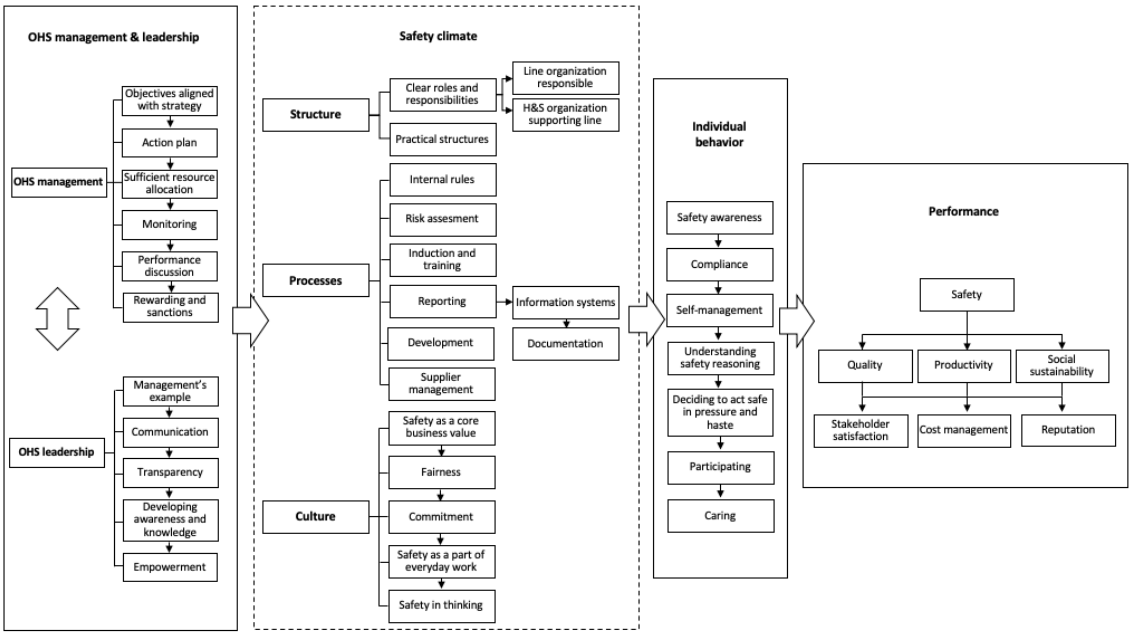


Figure 14. *The safety performance map.*

According to the study, the best starting point for OHS performance is in business strategy, which contributes to the vision. In some companies, safety may be clearly included in the strategy, but even if safety is not concretely reflected there, safety will support the realization of other parts of the strategy, such as profitability. Thus, safety objectives are set in accordance with the strategy. A road map, a strategy tool, is one way to align goals. A detailed plan of action is designed to reach the set objectives, thus, ultimately, to prevent safety issues and to address them. Plans and goals can be created locally and at the corporate level and at different time spans, such as annual or monthly. Next, management should make sure that there are sufficient resources available to perform the required safety actions, such as inspections, but also development, to meet the set action plan and the objectives.

Monitoring the achievement of objectives is considered essential. It allows management to demonstrate a commitment to improving safety and is also done for accountability reasons. Monitoring is done through indicators, such as audits and inspections. Monitoring then reveals performance. Performance discussion should be in place, before proceeding from determining rewards and sanctions according to the performance results. The discussion can be used to find out whether the accident was due to the employee's

negligent actions or, for example, the lack of adequate instructions or the right kind of work equipment. If the performance has been positive, the discussion can be used to communicate, appreciate, and encourage positive behavior. Only after that, the rewards and sanctions are addressed. However, the rewarding should not only be based on the results, but also according to active participation in safety actions.

The factors explained above are classified as belonging to OHS management, but management and leadership have a two-way relation, and they do not appear without each other. Management's example is shown through actions and discussions, and it seems to motivate employees' commitment to safety. The importance of informing and two-way communication of safety and health-related issues is highlighted, especially in everyday working life. Everyone in the organization should receive the necessary safety information, which in part creates transparency in the company. Also, open reporting and communication of accidents express transparency. Actions and communication both increase organization's members' awareness and knowledge of safety. There must be an overall picture, and a basic understanding of what OHS is, how it affects the company, and what are the legal requirements, but high competency in OHS is not needed. Empowerment expresses a higher level of maturity. It is about involving employees in decision-making and giving them independence so that individuals can use their awareness and knowledge for the benefit of the community. Table 9 summarizes all the factors under the perspectives of OHS management and leadership.

Table 9. *Summary of factors included in safety performance map under the perspectives of OHS management and OHS leadership.*

OHS management	**Description**
Objectives aligned with strategy	Setting visible, fair and achievable objectives in line with the organization's strategy.
Action plan	Creating an annual or monthly plan of action. Plan is designed to prevent safety issues and to address them.
Sufficient resource allocation	Ensuring there are resources available to perform the required safety actions, such as inspections and development work.
Monitoring	Monitoring the achievement of objectives. Monitoring allows management to demonstrate a commitment to improving safety.
Performance discussion	A discussion that can be used to encourage positive proactive performance or find out whether an incident was due to the employee's negligent actions or, for example, the lack of adequate instructions or the right kind of work equipment.
Rewarding and sanctions	Rewarding and sanctions according to results but also rewarding based on active participation in safety actions.
OHS leadership	
Management's example	Leading by example through discussions and actions. Management's example motivates employees' commitment to safety.

Communication	Informing and two-way communication. Safety issues are addressed in everyday life, and everyone receives the necessary information regarding safety.
Transparency	Transparency in safety related issues. For instance, accidents are reported openly.
Developing awareness and knowledge	There is an overall picture and a basic understanding of OHS, how it affects the company, and its legal requirements. High competence in OHS is not needed, but awareness of it is required.
Empowerment	Involving employees in decision-making and giving them independence so that individuals can use their awareness and knowledge to benefit the community.

The structure perspective of the safety performance map, that considers the hierarchy within an organization consists of four factors. The first factor, Clear roles and responsibilities, emphasizes that all members of the organization should be aware of what they can do to promote safety. This requires clear job descriptions and specifications. Usually, the line organization is responsible for implementing safety actions, and the H&S organization has a more supportive role. Also, the OHS structures should be practical and suitable for the company's needs. Depending on the company's current situation and industry, the roles and responsibilities might either need harmonization or flexibility.

There is a high number of processes in organizations, but the ones that ended up in the safety performance map include internal rules, induction and training, development, supplier management, and reporting, supported by the factors of information systems and documentation. The processes are continual, and thus they are not organized in a specific order, and no causal relationships have been found between them. The factors are explained in Table 10.

Under the cultural perspective, the factors are more abstract, but there are a clear relationship and order between the factors. The premise is that safety would be one of the core values of a company. Fairness, which here reflects equality and justice, is also often linked to company values. Once there is a value base, individuals in the organization can all commit to these shared values and take responsibility for their own and their colleagues' safety. Safety should be a part of each job description. It should not be treated as a function separate from other activities. In a mature culture, safety is part of all thinking and the first thing to pay attention to in all situations - safety first.

Table 10. *Summary of factors included in safety performance map under the perspectives of structure, processes and culture.*

Structure	**Description**
Clear roles and responsibilities	Understanding one's role and responsibilities - what can be done for safety. Clear job descriptions and specifications.

Line organization responsible	The line organization is responsible for implementing safety actions.
H&S organization supporting line	H&S organization is responsible for developing and planning safety actions as well as supporting supervisors in their safety activities.
Practical structures	OHS structures are practical and suitable for the company's needs. Either harmonization or flexibility could be required.
Processes	
Internal rules	An organization's set of rules specific to operations and industry. Rules reflect legislative requirements.
Risk assessment	The process of evaluating risks to individuals' safety and health in the workplace.
Induction and training	Job induction and training in safety and health, such as occupational safety card training.
Reporting	Reporting observations, near-misses and accidents.
Information systems	Information system as a tool for reporting and as a document storage.
Documentation	Documentation is available and accessible.
Development	Planning and development of safety-related actions at the workplace. Continual improvement process.
Supplier management	Ensuring the contractor has the ability to work safely.
Culture	
Safety as a core business value	Safety is one of the core business values.
Fairness	The culture reflects fairness and justice. Everyone is treated the same.
Commitment	Safety is dedicated: everyone takes responsibility for their own and their colleague's safety.
Safety as a part of everyday work	Understanding that safety is not a separate issue, but part of a job well done.
Safety in thinking	Individuals always want to make a safe choice in all situations.

Also, the factors identified under the individual behavior perspective are causally related to each other, and the order between them also reflects maturity levels. First, the individual should become safety aware; become aware of workplace hazards and the existence of safety instructions and procedures in the workplace. This is followed by compliance. Thus, individuals follow the safety rules even if they do not entirely understand why this is done and where the action's effect is. At an even more mature level, the individual is capable of self-direction, regulation, and management. The safety instructions are followed to the end, and even when no one is monitoring compliance. Next, individuals start to understand why safety is important and why certain activities are done to improve

occupational safety. Achieving this requires efficient leadership and communication. After individuals have a broad understanding of why safety is a priority, they should have the capability to work following safety instructions and make safe choices even when the work schedule is tight, and there are production pressures.

The highest maturity levels apply to participating and caring. First comes caring for safety matters, which here called participating. Individuals are involved, and they actively participate in improving safety in the workplace. Caring for people in the workplace includes taking responsibility for the safety of oneself and others. Caring includes intervention that can be expressed e.g., by intervening when seeing an unsafe act and giving feedback.

Table 11. *Summary of factors included in safety performance map under the perspective of individual behavior.*

Individual behavior	Description
Safety awareness	Awareness of dangers at the workplace. Awareness of the existence of safety procedures.
Compliance	Individuals follow the rules even if they do not entirely understand why.
Self-management	The safety instructions are followed to the end, and even when no one is monitoring compliance.
Understanding safety reasoning	Understanding why safety is important and why certain activities are done to improve occupational safety.
Deciding to act safe in pressure and haste	Employees work in accordance with safety instructions, even when the work schedule is tight.
Participating	Individuals are involved, and they actively participate in improving safety in the workplace. Caring for safety matters.
Caring	Caring for each other and taking responsibility for the safety of oneself and others. Caring can be expressed e.g., by intervening when seeing an unsafe act and by giving feedback.

The last section of the map, performance, describes what can be affected in performance through the perspectives and factors described above. The most self-evident is safety performance. However, safety also has indirect effects. It was identified that safety affects quality, productivity, and social sustainability, and, through these, further stakeholder satisfaction, cost management, and reputation. The factors are explained in Table 12.

Table 12. *Summary of factors included in safety performance map under the perspective of performance.*

Performance	Description
Safety	The quality of an organization's safety-related work, thus the ability to lower the risk of accidents.

Quality	Safety is a component of quality.
Productivity	Safety is seen to relate to improved productivity e.g., through less sickness absence.
Reputation	Accidents could have harmful impacts on reputation. Reputation has an impact on how attractive employees see the company.
Social sustainability	Promotion of i.e., wellbeing, equity, and human rights in the organization and the society around it.
Cost management	Successful OHS management can lead to cost management through both direct and indirect costs.
Stakeholder satisfaction	Safety is seen to have an impact on stakeholder satisfaction, for instance, through sustainability issues.

In a bigger picture, it seems that the chain ends to the factors under the perspective of performance. However, this is not the case in reality. The process is iterative: the safety performance map and the state of the factors on the map can be viewed at a particular point in time. Thus, a map can be used to look, for example, at how changes in one factor are reflected in other factors and performance.

6.1.5 Industry-specific features

The construction industry is characterized by the project-like nature of the work, which was evident in the interviews with the house construction industry company participating in the testing phase and the infrastructure company involved in the creation of the safety performance map. The interviews with these two companies revealed that project organization shows especially in the fact that the settings for the work are not permanent and business is geographically dispersed. Construction sites are essential part of the operational logic. The construction sites are dynamic environments: the construction site changes all the time and in a fast cycle according to the construction phases. Also, the employees involved move and change several times during the project. The assumption was that, the project nature of the construction industry would also reflect in the map as industry-specific features, such as the requirement for flexible OHS structures. However, what is noteworthy, it seems that is not the case. The house construction company did not identify flexibility as an essential requirement for their OHS related structures, although flexibility otherwise is a crucial part of their business. Instead, the company seeks to find harmonization at the group level.

On the other hand, the infrastructure company stated that they have a different organizational structure in all of their business units. Also, the manufacturing company that operates globally in several locations stated that it may not be possible to require the polices, roles and responsibilities to be identical in all of the company's units due to differentiating local legislations and regulation. Thus, more than the project nature of the

business, the fragmentation of operations and the requirement for flexibility may be explained by the large size of the company, the large number of units or the company's various business areas.

In the interviews with the construction sector companies, also culture was seen to be reflected by project work. According to the representatives of the house construction company, the project leader has a great impact on the working culture in the construction site. Some leaders might follow the safety rules more strictly than another leader in another project, which might cause sub-cultures to arise and cause confusion among employees. Also, the representatives of the infrastructure company had acknowledged the challenge of ensuring that cultural changes are proceed throughout the organization, when the company has units all over Finland, in which different professional groups all with different cultures work together. Although this issue of sub-cultures did not come up with the companies representing manufacturing industry, it might still be, that the explanation is the fragmentation of business similarly to the OHS structure issues rather than the industry sector itself.

Another factor describing construction industry is the fact that it is strictly regulated and supervised, and this seems to be truly an industry-specific feature. The construction industry is thus subject to its own regulations on the safety of construction work, and some indicators, for example, may have been developed specifically for the needs of the construction industry.

In conclusion, it can be assumed that the differing views or different emphases of companies on the factors contributing to safety performance are not necessarily so much related to the industry they represent, but also, for example, the size and geographical fragmentation of the company as well as the stage of the company's life cycle. In general, it is difficult to draw more general conclusions about how context affects outcomes. This would suggest that the safety performance map as an obtained result of the research, described with this precision, would be quite generally applicable.

6.2 How can the factors affecting safety performance be measured?

6.2.1 Current safety measures in the case companies

One of the aims of this research is to introduce key performance indicators (KPI) for different factors affecting safety performance that are illustrated in safety performance map. The first step of this was to link the existing safety performance measures used in the case companies and in the companies involved in the testing phase to the created

map. The purpose of the listing is to create an overview on how the companies measure the different factors of the map and offer the companies a chance to benchmark the indicators that other companies use. Table 13 presents the indicators used in the investigated companies. The listing may not be complete, and it should be noted that companies have reported the indicators used with different accuracies. Therefore, only in the case of some of the indicators the unit of measurement is mentioned. In addition, the table presents only the indicator, not the calculation formula or method.

Table 13. *Current measures used in the case companies for evaluating safety performance.*

Factor	Indicator	No. of companies	Lead / Lag
OHS M&L			
Sufficient resource allocation	Tracking overtime	1	Lead
Monitoring	Corrective actions are taken without delay	1	Lead
	Corrective actions per incidents & near misses	1	Lead
	Safety audits are held at all construction sites	1	Lead
	A manager always participates in the accident investigation	1	Lead
	Risk assessments update / new	1	Lead
	Completion of safety observations	1	Lead
Management's example	Safety walk	2	Lead
Communication	Safety Talks	2	Lead
	Weekly meetings are held regularly at all construction sites	1	Lead
	Meetings related to the maintenance of work ability *(In Finnish: Tyky-palaveri*)	1	Lead
Processes			
Internal rules	Rehabilitation work	1	Lag
	Health examinations	1	Lead
Risk assessment	Risk assessments	1	Lead
Induction and training	Safety training	1	Lead
	Induction rate	1	Lead
Reporting	Near-misses	1	Lead/ Lag
	SIF (Serious incidents and fatality) potential	1	Lag
Supplier management	Accident frequency of own employees and subcontractors (LTI 1)	1	Lag
	TRI accidents to suppliers	1	Lag
Culture			
Commitment	Employee satisfaction survey	1	Lead
Individual behavior			
Compliance	EHS observations	7	Lead
	TR safety observation method	2	Lead

	MVR safety observation method	1	Lead
	Elmeri+ safety observation method	1	Lead
Performance			
Safety	LTI (Lost time injury rate)	4	Lag
	Accident rate of own employees (LTI 1)	*1*	*Lag*
	Serious accident rate of own employees (LTI 9)	*1*	*Lag*
	TRI (Total recordable incident rate)	4	Lag
	TRIF (Total recordable incident frequency)	3	Lag
	Sick leave	2	Lag
	(Suspected) occupational diseases	2	Lag
	LTA (lost-time accident rate)	5	Lag
	Percentage of hours worked	1	Lag
	Severity rate	1	Lag
	SIF exposure	1	Lag
	MTI (Medical treatment injuries)	1	Lag
	First aid cases	1	Lag
	Accidents on the way to and from work	1	Lag
Productivity	Lost days	3	Lag
	Lost time	1	Lag
	Worked hours	1	Lag
Cost management	Accident costs	2	Lag
	The development of the accident insurance premium	1	Lag
	Salary costs of sick leave caused by an accident	1	Lag

The four most commonly used indicators in the group of seven investigated companies are safety observations, lost time injury rate (LTI), total recordable incident rate (TRI), and lost time accident rate (LTA). Safety observations are made in all surveyed companies. In addition to safety observations, some companies mentioned industry-specific safety observation indicators, such as MVR and TR. TR safety observation method is used for measuring occupational safety specifically at construction sites, whereas MVR is an indicator for civil engineering. Another safety observation method mentioned was Elmeri+. This method is not as highly industry-specific, but it is described to be especially suitable to the industrial sector. Safety observations can be seen as an indicator for individual behavior in companies, but as individual behavior and culture are closely related, safety observations can also be linked to the perspective of culture.

It can be seen from the list that the indicators used are quite similar in all the companies surveyed and the indicators present quite traditional safety measures. The fact that not all companies have mentioned an indicator that is on the list does not mean that that

indicator, process or activity is not used in the company. For example, safety training is statutory, but still only one of the companies interviewed mentioned safety training when asked about indicators. This may be due, for example, to the fact that the given list of indicators is not complete or that training is simply not considered a measurable object in the company. Many of the companies probably emphasized OHS indicators, but at the same time it is likely that for example many HR indicators went unreported. However, it is important to note, that for the map as a whole, it would be essential to interconnect the measures for all areas and perspectives.

Overall, it is evident that lagging measures are principally used to measure the right-hand side of the safety performance map, i.e. the end result of the safety actions. On the contrary, proactive measures are used to measure the left side of the map, which includes the factors that can be influenced proactively to achieve enhanced safety performance.

6.2.2 Identification of possible development needs in measurement

As noted in the previous subsection, there are not many indicators associated with the OHS structure, but on the other hand, structure is not perceived as a traditional and essential measurement object in safety management. It can also be seen from the table that there are not many indicators available for companies to measure culture either. The desire and willingness to find such culture measures were also expressed in several interviews conducted within this project. The measurement of culture is further elaborated in another part of the SafePotential project, but this study also aims to present some indicators for measuring the different identified areas of culture.

Another development need identified in the project interviews is related to leading indicators. Many of the case companies addressed their interest in finding new leading indicators for measuring safety performance. The companies were willing to find more positive measures instead of focusing only on the traditional lagging indicators. At the moment, when looking at the indicators of all companies in Table 13 as a whole, the number of leading and lagging indicators seems to be about the same. However, the literature has identified that there could be relatively more leading indicators than lagging indicators in the companies' safety measurement systems.

It could be seen from Table 13 in the previous subsection that there are multiple key factors affecting safety performance which are currently not measured in the case organizations. Instead, the current indicators seem to measure only few of the identified key factors. In order to target development work more precisely, it would be meaningful

to have indicators that focus more closely on measuring the various specific factors that contribute to the development of safety performance. The next sub-chapter seeks to solve the challenge identified here by presenting a comprehensive list of proactive indicators associated with different factors contributing to safety.

6.2.3 Linking proactive measures in the academic literature to the map

This sub-chapter continues to answer the second research question by presenting the indicators identified in the literature and linking them to the factors of the safety performance map. The idea is to offer companies new measures for measuring safety performance in particular from a proactive point of view. Another purpose is to fill in the gaps identified in measuring the different factors contributing to the formation of safety performance. Thus, in contrast to the table presenting the existing indicators for companies, all the safety performance factors identified are presented in this list.

Many of the articles reviewed presented indicators suitable for a specific industry, but more universally valid indicators have been sought to be presented in the listing here. It should also be noted that the number of indicators proposed in the covered literature was vast, and the listing only contains examples of those. The indicators were selected from the literature so that there would be indicators linked to each of the factors and no factor would be excessively emphasized. In the literature review on indicators in sub-chapter 4.5. Safety performance indicators in the literature, a considerable number of literature sources are covered. However, quite a few of the sources studied presented indicators suitable for measuring the factors on safety performance map. For this reason, many of the measures presented are from the same sources. The possible indicators are presented grouped under the main perspectives of the safety performance map.

Table 14 first proposes the discovered indicators in relation to OHS management and leadership. There are multiple indicators presented in the literature to be associated with the factors under these two perspectives. Especially the factors of resource allocation, monitoring and communication are broadly discussed in the literature and several measures are proposed for evaluating them. The factors identified to belong under the management and leadership perspectives are discussed in fairly similar terms in the literature, most of the terms are not very ambiguous and the factors are commonly identified as part of the management system. Therefore, the classification of indicators is quite straightforward at this point.

The list of indicators contains both quantitative and qualitative measures. Reiman and Pietikäinen (2010) presents qualitative indicators. Such indicators' results are usually

presented as ‘yes’ or ‘no’ responses or evaluated using a Likert scale. Reiman and Pietikäinen (2010) however states that presented indicators does not necessarily serve as actual measures, but rather guides the attention to relevant factors. Considering this, the implementation of the indicators, might mean that the organization would be to develop for example a survey to evaluate the extent to which these indicators are met. The indicators from other researches listed are evaluated quantitatively, as a frequency or a percentual figure.

Table 14. *Examples of indicators presented in the literature with relation to the factors of OHS management and leadership.*

Factor	Indicator
OHS management	
Objectives aligned with strategy	Number of measurable OSH improvement goals established in the enterprise (Podgórski 2015)
	Safety goals are defined both for short and long term (Reiman and Pietikäinen 2010)
	Safety goals are relevant for the organization (Reiman and Pietikäinen 2010)
Action plan	There is an action program for reaching the safety goals (Reiman and Pietikäinen 2010)
Sufficient resource allocation	Costs assigned to HSE for preventing accidents (per each worker per year, and with respect to total expense) (Amir-Heidari et al. 2017)
	The availability of sufficient workforce is ensured (Reiman and Pietikäinen 2010)
	Tools and instruments are appropriate and up to date (Reiman and Pietikäinen 2010)
	Human performance issues such as fatigue and communication are taken into account in work schedule planning (Reiman and Pietikäinen 2010)
Monitoring	Percentage of completion of activities related to risk assessment and control in the planned times (Amir-Heidari et al. 2017)
	Number of leading vs. lagging performance indicators monitored to measure OSH management performance (Podgórski 2015)
	% of definitions of leading and lagging performance indicators subject to periodical review and update (Podgórski 2015)
Performance discussion	Positive feedback is given on safety conscious behavior of the personnel (Reiman and Pietikäinen 2010)
Rewarding and sanctions	The no. of rewards given to workers for OHS hazard reports (Mohammadfam et al. 2017)
	The no. of rewards for participating in OHS activities (Mohammadfam et al. 2017)
	The no. of OHS violations, & no. of sanctions (Mohammadfam et al. 2017)
OHS leadership	
Management's example	How often management walks on the floor (OHS best practices 2015)
	Percent of jobsite toolbox meetings attended by jobsite supervisors/managers (Hinze et al. 2013)
	Percent of jobsite pre-task planning meetings attended by job-site supervisors/managers (Hinze et al. 2013)
	Management is actively committed to, and visibly involved in, safety activities (Reiman and Pietikäinen 2010)
Communication	Rating of the effectiveness of OSH communication via workforce survey (Podgórski 2015)
	How often safety is discussed at meetings (OHS best practices 2015)
	How many different avenues the organization uses to communicate OHS messaging (OHS best practices 2015)

	There are both formal and informal communication channels for raising safety concerns in the organization – up to the highest level if necessary (Reiman and Pietikäinen 2010)
	The bottlenecks of information flow have been identified and controlled (Reiman and Pietikäinen 2010)
	Information flow in change of shifts situations is assured (Reiman and Pietikäinen 2010)
Transparency	Reporting of deviations, worries and own mistakes is encouraged by the management (Reiman and Pietikäinen 2010)
	The personnel are informed about the overall safety level and current challenges on a regular basis (Reiman and Pietikäinen 2010)
	The extent to which the decision making in the organization utilizes all the necessary competence and is transparent in its content and progress (Reiman and Pietikäinen 2010)
Developing awareness and knowledge	% of workers declaring good knowledge of OSH policy of the enterprise (Podgórski 2015)
Empowerment	Variety of views and opinions are encouraged, and decisions are based on expertise not formal position (Reiman and Pietikäinen 2010)
	The know-how of the "shop-floor" personnel is utilized in creating and revising of rules and instructions (Reiman and Pietikäinen 2010)

The most descriptive factor of the structure perspective is Clear roles and responsibilities. As the factors Line organization responsible and H&S organization supporting line are considered as components of the factor Clear roles and responsibilities, the indicators found on these three categories are merged. There were no indicators found in the literature covered to fit in the theme of Practical structures. For the purposes of the safety performance map Practical structures is described to mean OHS structures that are suitable for a company's specific needs depending on industry, size, and stage of development. Also, for this reason, the universally applicable measures are difficult to develop.

Processes include factors that are more widely acknowledge to be a crucial part of safety management system, such as risk assessment, training, and supplier management. Risk assessments are considered themselves as leading indicators, but also the effectiveness and use of them can be measured.

Culture revealed difficult to be measured as also was assumed in advance. The challenge might be its abstractness and intangibility of the factors identified to describe culture. Also, in many researches studying culture, the components of safety culture were partially the same than the factors linked to OHS management and leadership or Processes in safety performance map. For example, communication and training were seen to be sub-components of culture (Gordon et al. 2007; Reiman and Pietikäinen 2010; Tappin et al. 2015). However, the difference in interpretations can be explained, as also according to the description of the safety performance map, the main levels are interconnected and management is seen as influencing culture and also culture and processes are linked, forming a safety climate. This observation could denote that the level of cul-

ture could also be indicated by indicators belonging to other categories. A little surprisingly, although the role of commitment is emphasized widely in the safety management literature, not many indicators were found for measuring the commitment. Examples of indicators relevant for measuring the different factors of structure, processes and culture are shown in Table 15.

Table 15. Examples of indicators presented in the literature with relation to the factors of structure, processes and culture.

Factor	Indicator
Structure	
Clear roles and responsibilities (Line organization responsible) (H&S organization) supporting line	Percentage of work posts with defined OSH responsibilities and duties (Podgórski 2015)
	% of workers declaring awareness of their duties and responsibilities with regard to OSH MS (Podgórski 2015)
	The clarity of the organizational structure including the extent to which roles and responsibilities have been clearly and unambiguously described (Reiman and Pietikäinen 2010)
Practical structures	No indicators found.
Processes	
Internal rules	Number of OSH policy reviews and updates carried out by top management (Podgórski 2015)
Risk assessment	% of workstations with risk assessment documented and risk control measures planned to be implemented (Podgórski 2015)
	% of risk assessment processes completed and documented (in relation to established plans) (Podgórski 2015)
	% of workstations with risk levels assessed as medium to high (requiring planning of risk control measures) (Podgórski 2015)
	The no. of risk assessments carried out in units (Mohammadfam et al. 2017)
Induction and training	Number or percent of management personnel and field employees with 10-h (or 30-h) OSHA certification cards (Hinze et al. 2013).
	Percentage of workers participating in OSH refresher courses (Podgórski 2015)
	% of right answers per persons from tests to evaluate the effectiveness of OSH training (Podgórski 2015)
	Feedback is gathered from the trainees and it is utilized in developing the training program (Reiman and Pietikäinen 2010)
	Percentage of OSH training courses reviewed and improved for their quality and effectiveness (Podgórski 2015)
	What per cent of the workforce has OHS training beyond basic legislated compliance (OHS best practices 2015)
	Competence is maintained for both new and old technology (Reiman and Pietikäinen 2010)
	Simulators and simulated operations are utilized in training (Reiman and Pietikäinen 2010)
	Operating events (own plant as well as outside) are utilized as training material (Reiman and Pietikäinen 2010)
	There is regular training on emergencies on-site (Reiman and Pietikäinen 2010)
Reporting	There is a comprehensive system for reporting incidents and other learning experiences such as near misses (Reiman and Pietikäinen 2010)
	The no. of units that have an OHS reporting system (Mohammadfam et al. 2017)
	The no. of OHS performance reports from units (Mohammadfam et al. 2017)

Information systems	There is a system for documenting history data on equipment and their maintenance actions (Reiman and Pietikäinen 2010)
	The no. of units in which OHS report & record-keeping systems exist (Mohammadfam et al. 2017)
	Assessment of technological solutions, available on market, for increasing efficiency of safety system (Janackovic et al. 2020)
Documentation	History data is used in analysis of reliability and maintenance needs of the equipment (Reiman and Pietikäinen 2010)
	The quality of documentation and procedures (Reiman and Pietikäinen 2010)
Development	There is a procedure to ensure that key safety issues are addressed in the design and engineering phase of the plant and its components (Reiman and Pietikäinen 2010)
	There is a procedure to maintain and update the plant design basis documentation (Reiman and Pietikäinen 2010)
	Number of analyses of impact on OSH carried out with regard to changes in OSH regulations, technologies and knowledge (Podgórski 2015)
Supplier management	Number of contractors assessed for their compliance with OSH management requirements (Podgórski 2015)
	Number or percent of subcontractors selected, in part, on the basis of satisfying specific safety criterion prior to being awarded the subcontract (Hinze et al. 2013)
	Requirement that each subcontractor submit a site-specific safety program that must be approved prior to the performance of any work by that subcontractor (Hinze et al. 2013)
	Contractors have possibilities for expressing safety worries and providing safety proposals on issues they notice (Reiman and Pietikäinen 2010)
	Vendor exit debrief: Percent of exit interviews that include identified hazards, unsafe behaviors or incidents (Hallowell et al. 2013).
	Vendor safety audits: The percentage of vendors in compliance with site policies and procedures (Hallowell et al. 2013).
Culture	
Safety as a core business value	Safety is a clearly recognized value at the organization (Reiman and Pietikäinen 2010)
Fairness	Superior provides fair treatment of subordinates, understanding that errors are natural, but not all violations can be tolerated (Reiman and Pietikäinen 2010)
Commitment	Management is actively committed to, and visibly involved in, safety activities (Reiman and Pietikäinen 2010)
	Owners show commitment to safety activities (Reiman and Pietikäinen 2010)
Safety as a part of everyday work	The percentage of pretask plans prepared for work tasks (Hallowell et al. 2013)
Safety in thinking	Attitude Survey, questionnaire (In Swuste et al. 2016 (Eindhoven TU in the Netherlands))

Although Reiman and Pietikäinen (2010) studied particularly the indicators of safety culture, many of the indicators presented in their paper can be associated with the factors identified under the heading individual behavior in the safety performance map. However, because the factors identified under the individual behavior heading are quite close to each other and concepts such as self-management and caring are quite abstract, it is challenging to identify measures that are unambiguously suitable for measuring the factor. Table 16 presents examples of indicators presented in the literature with relation to the factors of individual behavior.

Table 16. *Examples of indicators presented in the literature with relation to the factors of individual behavior.*

Factor	Indicator
Individual behavior	
Safety awareness	The extent to which the personnel understands the hazards that are connected to their work (Reiman and Pietikäinen 2010)
	The extent to which the personnel understand the safety significance of their own tasks (Reiman and Pietikäinen 2010)
Compliance	Whether hazard assessments are actually being completed and workers are involved in the in the process (OHS best practices 2015)
	Percent of safety compliance on jobsite safety audits (inspections) (Hinze et al. 2013).
Self-management	The extent to which the personnel have a willingness to spend personal effort on safety issues and take responsibility for their actions. (Reiman and Pietikäinen 2010)
	The extent to which the personnel have a sense of personal ownership for an equipment, an area of plant or the entire operations of the plant. (Reiman and Pietikäinen 2010)
Understanding safety reasoning	The extent to which the personnel have basic knowledge of human performance issues (Reiman and Pietikäinen 2012)
	The extent to which the defense-in-depth principle is understood among the personnel (Reiman and Pietikäinen 2012)
Deciding to act safe in pressure and haste	There is a system for ensuring that time pressure does not compromise quality in safety-critical tasks (Reiman and Pietikäinen 2010)
	The extent to which the personnel prioritize safety over production in conflict situations or under time pressure (Reiman and Pietikäinen 2010)
Participating	Personnel participate in setting safety goals (Reiman and Pietikäinen 2010)
	Number of suggestions for safety improvements (Swuste et al. 2016)
	Rating of effectiveness of workers' participation in OSH management via workforce survey (Podgórski 2015)
	The no. of accident investigations carried out with worker participation (Mohammadfam et al. 2017)
Caring	The extent to which the personnel at all levels exhibit a questioning attitude (Reiman and Pietikäinen 2010).
	The extent to which the personnel remain humble toward their knowledge of the hazards and their competence (Reiman and Pietikäinen 2010).

When safety is discussed as an end result, the level of safety is often measured using lagging indicators. Also, because the purpose of the map and the indicator listing is to study the factors and subject around the theme of safety, the subject of safety itself is excluded from here. Although the relationship between safety performance and other organizational benefits has been studied quite extensively (e.g., Fernández-Muñiz et al. 2009; Veltri et al. 2007), studies seldom suggest measures for evaluating safety-related benefits. Köper et al. (2009) studied the employee health-related issues and their relation to business benefits such as quality, productivity, cost reduction, and absenteeism, and proposed indicators for measuring those. Otherwise, indicators for these categories can possibly be found at a more general level in the literature on performance measurement and management accounting, but the challenge may be to measure the extent to which safety has contributed to performance improvements and what is due to other factors. Table 17 describes the measures linked to the other organizational effects of successful safety activities.

Table 17. *Examples of indicators presented in the literature with relation to the factors of organizational performance.*

Factor	Indicator
Performance	
Quality	Defective product rate: negative deviation from estimated defect product rate (i.e., high figure stands for low defect rates and therefore high quality) (Köper et al. 2009)
	Rework: absolute figures per cost centre (Köper et al. 2009)
Productivity	Productivity figure: negative deviation from target productivity (i.e., a low figure stands for high productivity) (Köper et al. 2009)
	Asset efficiency: negative deviation from target (i.e., a low figure stands for high productivity) (Köper et al. 2009)
Reputation	Degree of satisfaction on a 5-point Likert scale (Fernández-Muñiz et al. 2009)
Social sustainability	Superior monitors the personnel's coping skills, stress and fatigue levels as well as technical skills (Reiman and Pietikäinen 2010)
Cost management	Absolute figured per cost centre (Köper et al. 2009)
	Analysis of costs of occupational injuries (Janackovic et al. 2020)
Stakeholder satisfaction	Degree of customer satisfaction on a 5-point Likert scale (Fernández-Muñiz et al. 2009)

As already noted in the categorization of the indicators used by companies, many of the indicators are such that they may be suitable for more than one factor in the safety performance map. For example, the indicator "Personnel participates in setting safety goals" from Reiman and Pietikäinen (2010) that is now linked to the factor Participating under the perspective of Individual behavior could also be linked, for example, to the factor Objectives aligned with strategy. This fact emphasizes the fundamental nature of the formation of the safety performance and, at the same time, the safety performance map: ultimately, the connections are rather complicated, and most of the factors are related somehow.

6.3 Validation of the model usefulness: Evaluation of the usefulness of the map and the proposed indicators in a food industry case company

The safety performance map was used at the food industry company to study the coverage of current performance measures. By first linking the measures used in the whole company at the group level to the main perspectives of the map, it was found that most of the indicators could be linked with the right edge of the map. The connected perspectives and the indicators were the following:

- Culture and Individual behavior: Risk observations
- Processes: Risk assessment, rehabilitation work

- Organizational performance: Incidents, accidents, injuries, frequencies, severity, lost days, lost time, and worked hours.

Thus, based on the analysis, it appears that the company has very few indicators to measure culture, behavior, or processes, and no indicators at all to measure factors related to management or structure. Linked to the individual factors on the safety performance map, risk observations are related to compliance, rehabilitation work to internal rules, incidents, accidents, injuries, frequencies, and severity to safety and lost days, lost time as well as worked hours to productivity. The focus of the measurement is currently at the measurement of LTI and in Vision Zero targets. Consequently, the safety performance measurement at the food industry company seems to be more focused on measuring the performance outcomes with lagging indicators than measuring proactively the factors contributing to the development of a safe working environment. A representative from the food industry company commented it was eye opening to notice that the OHS management and leadership perspective, which they consider to be the most essential aspect, is not measured at all.

Most of the indicators used at the company are reactive measures. In fact, risk observations, as well as risk assessments seem to be the only leading measures currently. The finding did not come as a surprise for the company, but they acknowledged the need to emphasize proactive actions and develop new leading indicators to manage better the process that contributes to safety.

The safety performance map was also used to provoke discussion on how the company sees the factors on the map from the measurement perspective. The aim was to identify factors about which it is particularly important to obtain information. The discussion with the food industry company revealed that the company would like to develop the measurement of commitment and particularly managers' commitment to safety. Another central theme mentioned for measurement development is monitoring and tracking the action to ensure that actions and procedures are implemented. The company had noticed that the problem sometimes is that many actions are implemented, but they do not have the expected effects. Thus, the company would be willing to measure the efficiency or implementation rate of an action and find out how much time the implementation takes. Because the company's units are located in several different countries, the comparability of results is essential for allowing benchmarking between the units. The need to develop the measurement of culture also emerged, but as previously stated, the topic is mainly sidelined in this study, since as a part of the SafePotential project, there will be research focusing on this topic specifically.

After the gaps in the safety measurement were identified based on the usage of the safety performance map and the company interview, examples of the indicators gathered from the literature and other case organizations were presented to the company to evaluate which of the proactive measures the food industry company could test or apply to their needs. The exercise revealed that in reality, the company actually utilizes many of the activities related to presented indicators, but it seems that the company does not consider the activities as indicators, at least not clearly safety-related indicators, or does not measure them systematically. Another explanation for this might also be that as the company's organization has recently been reformed, not all indicators are yet in place at the group level. For example, it was stated at the interview that some of their sites already measures the completion of actions, while other sites do not have yet the systems for follow-up. Also, for example, safety walks were already utilized in the organization, but again not on the group level.

Generally, at the company the presented measures focusing on quantity, for example the amount of communication events, were considered as poor measures. According to the interviews the focus should be more on measuring quality of the actions. In connection with this purpose, the indicators presented by Reiman and Pietikäinen (2010), for example, were also found to be of interest at the company. The workshop also awakened the company to generate ideas for new indicators. Ideas for possible new indicators included i.e. the number of downloads on the intranet to indicate successful communication and the number of online trainings conducted.

The validation showed that the map can be used to identify factors that are not currently measured. The food industry company's aim is to harmonize the different practices of the different units, and the map could perhaps also be used as a tool in this work. The map could possibly be used to identify the differentiating safety activities and measurement practices. It seems evident that the map is suitable to be used to evaluate performance measurement status, support the implementation of safety strategies and as a tool for communication. Although the company did not directly find the right indicators for their needs in the examples of indicators presented, such a listing can be considered to have provided the company with ideas and incentives to develop more suitable indicators for their specific needs.

7. DISCUSSION

The safety performance map described in this research was constructed as a depiction of the factors supporting the achievement of the desired level of safety. In occupational health and safety management literature, the focus has typically been on describing shorter relations or individual factors of smaller entities, rather than describing the whole chain in a detailed level. Wu et al. (2008) examined the relation between safety leadership, safety climate and safety performance and Tappura et al. (2015) have described leadership's impact on organizational performance. More detailed level factors, components or activities and their association to suitable indicators have been studied, for example, by Reiman and Pietikäinen (2010), Podgórski (2015) and Mohammadfam et al. (2017). However, these studies did not focus on describing the entire network of issues related to occupational safety. Thus, this study adds to the literature of safety performance by comprehensively describing the factors and sub-units affecting OHS performance. Furthermore, to the existing studies, the map adds value by outlining the relationship between the factors and the safety maturity of the company, although the relationships were not exhaustively verified, and the topic should thus be further investigated.

Many of the findings related to the safety performance map are widely supported in the literature. This was particularly the case for OHS management and leadership, as well as for organizational performance factors. Köper et al. (2009) identified improvements in quality, productivity and cost management to be organizational impacts of successful safety management. Similarly, for example, Veltri et al. (2007) found that safety benefits include quality and productivity, but they also hypothesized that the potential benefits might also include stakeholder satisfaction and reputation, which were also identified in this study. In contrast, social sustainability was not mentioned in the previous literature as a safety benefit.

Considering the OHS management and leadership the factors, such as communication, rewarding, resource allocation, role modeling and empowerment are related to OHS performance in several studies (e.g. Vredenburgh 2002; Mearns et al. 2003; Grabowski et al. 2007; Fernández-Muñiz et al. 2009; Hale et al. 2010; Lingard et al. 2011). Instead, for example, transparency would seem to have emerged on the map as a new perspective compared to previous studies. However, the map also seems to lack factors that have previously been identified as important parts of safety management. For example, accountability has been identified in the literature as an integral part of the OHS management process (Sheehan et al. 2016). Also, the experts panel brought up accountability

as a missing factor while evaluating the first version of the map. However, as the factor was not more widely under discussion, it was left out. It needs to be considered whether some other factor on the map encompasses the concept of accountability, i.e. whether managers do what is agreed, or whether it is entirely missing from the description.

It is noteworthy that although management commitment has generally been highlighted in the literature as one of the most relevant factors influencing OHS performance (Lin and Mills 2001), management commitment has not been pointed out as a separate factor in this model. Instead, commitment has been seen to be reflected in other factors under the perspectives of OHS management and leadership. However, this is not a completely different view from the literature, either. Similarly, to the interpretation of this research, according to the literature, the managers' commitment can reflect, for example, the allocation of resources to safety activities (Fernández-Muñiz et al. 2009) and behaving as a role model (Lingard et al. 2011, Zohar 2010). Furthermore, in this thesis, the commitment has been seen as an essential part of the culture. This, as well as the choice of words individual behavior instead of the term employee behavior, emphasize the commitment of all members of the organization to safety, rather than only leaders'.

The safety performance map aims to offer a generalizable model for observing the formation of safety performance. Also, the indicators are such that they are thought to be more widely applicable despite the industry of the organization. Although on a more general level, clearly industry-specific characteristics were not found, when the organizations proceed to a more detailed level in the development of performance measurement system with the help of the findings of this research, also the company-specific features, such as the industry, the size of the company, the specific features of the organizational structure, the geographical location, and the stage of development of the company should be considered as proposed by Podgórski (2015). For example, it seems that strict regulations in the construction sector define the indicators fairly precisely, and the level of maturity of an organization's safety affects what kind of indicators a company should choose.

The map is a concise description, which also lacks some factors, perspectives and details that came up in the workshops. Although the map goes deeper than many models previously found in the literature, the factors have not been described at a very detailed level. All the above is about standardization, which is also a relevant challenge for defining the indicators, primarily the leading indicators. The challenge with the leading indicators is that they are often qualitative, and thus not measured by numbers. In this case, the measurement is not based on a standardized formula, but the evaluations are generally subjective and lengthy (Reiman and Pietikäinen 2012). Therefore, although the

study has proposed only leading indicators as new indicators and they are of interest to companies, for practical reasons, the measurement system should also include lagging indicators, since most of the lagging indicators are standardized (Lingard et al. 2011). The standardized results are to be reported, for example, to an insurance company. The results of the lagging indicators also allow comparison between companies, which is essential for managing occupational health and safety. It should be pointed out that the proposed indicators are interrelated, and even though they have been associated with certain factors, in practice, many of the indicators are likely to affect more than one factor.

8. CONCLUSIONS

8.1 Main findings

The objective of this research was to determine the factors that influence a company's safety performance, gain understanding of the relationships between these identified factors and find indicators for measuring each of them. To achieve the objectives this thesis aimed at answering the two main research questions constructed in the beginning of the research. Next, the research questions and the answers to them are presented condensed.

RQ1. What are the key factors affecting safety performance?

The first research question was answered in chapters 3.4 Synthesis: Framework for OHS management and organizational performance and 6.1 What are the key factors affecting safety performance? To answer the first question, this research has presented a framework – the safety performance map – which illustrates the factors influencing a company's safety performance. The complete map is described in the sub-chapter 6.1.4 The final version of the safety performance map.

The framework was based on theories presented in the literature and then supplemented through a series of workshops involving companies from different industries. Based on existing literature, the chain contributing from safety activities to generate the desired level of safety and other organizational performance was deemed to consist of eight perspectives: OHS management & leadership, culture, processes, structure, safety climate, individual behavior, OHS performance, and organizational performance. This developed framework combines the viewpoints of the organizational triangle (Guldenmund 2010), the framework of leadership's impact on organizational performance (Tappura et al. 2015), the framework of leader's characteristics and behavior to employees' job attitudes and behavior (Yukl 2010), and the framework on the relationship between safety leadership, safety climate and safety performance (Wu et al. 2008). In the final version of the map, OHS performance is merged into organizational performance, as suggested by Fernández-Muñiz et al. (2009).

Each of the perspectives, in turn, consists of a different amount of more detailed factors. Some of the factors are interrelated and the mutual order of the different factors in the chain can, in some part, be linked to the maturity of the OHS performance. The evaluation of the usefulness of the map demonstrated the validity and practical utility of the

framework as a tool for reveal the coverage of the current measurement of companies in relation to the representation of performance factors on the map. Based on the evaluation the map also works as a mean for OHS communication.

RQ2. How can the factors affecting safety performance be measured?

The second research question was discussed in chapter 6.2 How can the factors affecting safety performance be measured? In subsection 6.2.1 Current safety measures in the case companies, first, the existing safety performance measures used in the four case companies surveyed and the measures used in the companies involved in the testing of the map were examined. When the indicators were combined with the factors of the map, it was noticed that companies tend to use a lot of traditional lagging indicators, which focus mainly on measuring the result, i.e., the level of safety. In contrast, companies had little access to leading qualitative indicators to examine the upstream of the chain and “softer” factors and topics contributing to safety, such as management success or culture. Also, the indirect effects of safety on organizational performance were hardly measured.

In subsection 6.2.3 Linking proactive measures in the academic literature, the knowledge of suitable measures for measuring the different factors was supplemented with the proactive measures identified from the literature. It was found that there are proactive indicators for measuring most of the factors influencing the formation of safety. Many of these measures are qualitative in nature and precise definitions of indicators are quite seldom published.

8.2 Reliability and validity

The same requirements set for sound performance measurement, the most important of which are reliability and validity, are also used to evaluate the credibility of the research. Saunders et al. (2019, pp. 815) define reliability as follows: the extent to which the data collection method produces consistent results, the extent to which different researchers would make similar observations or conclusions, and the extent to which data are interpreted transparently. The validity, in turn, refers to examining what is meant to be examined. According to Saunders et al. (2019, pp. 820), validity can be examined from two perspectives: how accurately the chosen method measures what was intended to be measured and do the research findings relate to what they claim to be about.

The study's strength was the diverse set of case companies representing a wide range of different industries. The advantage of a multiple case study is that multiple cases increase external validity and reduce possible observer bias (Voss et al. 2002). Efforts

have also been made to prevent errors caused by the researcher by the fact that several researchers have been involved in conducting the research and facilitating the workshops.

A rich qualitative material was collected from the workshops. In the workshops, researchers had the opportunity to receive immediate feedback to develop the framework further. The created structure of theme interviews allowed the interviewers to take care that all the themes were reviewed. On the other hand, as the interviews were only semi-structured, the interviewees had an opportunity to bring up viewpoints outside the structured frames.

The challenge in the reliability of the study is the interpretation of the collected qualitative data. The challenge is that data sets collected from workshops and interviews are often large, and their content is complex (Saunders et al. 2019, p. 653). Also, the interpretation is always somewhat subjective. Thematic analysis of qualitative data involves coding of data that cannot be considered unproblematic. Coding involves challenging decisions about how delimited in detail the category or code should be. When a combined category that bundles as many answers as possible is chosen, as has been done in this study, one must make interpretations about whether something belongs to a category.

To improve the reliability of the data analysis, a participant review was conducted: the interpretations that emerged from the results of the analysis were reviewed by discussing the first versions of the created map with the workshop participants. This ensured that the material collected corresponded to the views of the interviewees. The interviewees' views can also be subjective and influenced by the interviewee's backgrounds and interests. There were several participants in the workshops, among whom a shared vision was formed, and thus the subjective view of individuals could be reduced. The results of the study were found to be, to some extent, parallel to the findings of the previous academic research, which can be considered to increase the reliability of the study.

The credibility of the study is further enhanced by testing the created map in three new companies from different fields, as well as by a group of experts who participated in some workshops, reflecting the findings on known safety management theory and previous research. Thus, generalizability has been created not only by generalizing observations to similar industrial environments but also relative to theory by broadening and confirming previous findings.

The study's limitation is that the validation of the results focused mainly on the first research question, i.e., testing the safety performance map. Instead, testing of the presented indicators received less attention in the study. Although the indicators' usefulness

was considered in one case company, the indicator list was not yet complete at this stage but contained only examples of possible indicators. The results of the evaluation were also not very clear or significant. Thus, the suitability of the indicators for measuring the linked factors nor the functionality of the indicators in general was not confirmed in the study. It may be that the more detailed design and definition of leading indicators needs to be done for company-specific needs, and thus this topic requires more in-depth case studies that focus solely on this aspect.

8.3 Practical implications

This research aimed to create a general framework for safety management. The developed framework serves as a good basis for a manager intending to identify the essential factors contributing to safety performance and shed light on what factors a company could measure to realize the potential of the measurement data.

The study involved companies from several industrial and construction sectors, and therefore the results can be deemed applicable in different industries. Even if the perspectives and factors affecting safety performance are esteemed to be close to identical in different industrial sectors, the relative importance of these factors may differ. The themes may also be specified according to some interesting or topical perspectives of each company or industry.

The safety performance map should not be considered an exhaustive description of factors contributing to OHS performance, but as a helpful tool in identifying the factors that are relevant. The safety performance map is proposed to be used for evaluation of the status of performance measurement, forming the hierarchy in information systems and reports, supporting the implementation of safety strategies, and highlighting the link between safety investments and performance impacts. The visual description can also be used as a means of OHS communication.

The indicators presented in the thesis are not intended to form a comprehensive listing of what kind of measures companies should have at their measurement system, but the purpose of the listing is to offer ideas on how the different proactive factors affecting safety could be measured with leading indicators. It clearly seems that in companies, the “soft” subjective and qualitative measurement is lacking, although it is needed to comprehensively understand safety management. From an extensive list of indicators, it may also be possible to select measures that take into account the specifies of a particular organizational unit. The proposed indicators can be used, for example, as a one-off study to find out the status of a single factor in a company.

The suitability of the proposed measures for measuring a specific factor was not tested in the research. The indicators should be evaluated concerning criteria, such as validity, reliability, relevance, and practicality of the measure. The testing and implementation would first require defining the precise name of the indicator, the desired level of performance, and the time required to achieve the level, the measurement frequency, and the exact formula of how the measurement result is calculated (Neely et al. 1997).

The new information provided by the indicators can be used in the companies for multiple purposes. for example, for the purposes of trend monitoring, reporting strategy implementation, forecasting, supporting rewarding system, directing employees, supporting decision-making or benchmarking either internally against the own organization's results from different units or externally to companies in the same sector. It is likely that the perspectives on the safety performance map may differ from each other in terms of purpose of use. Presumably the indicators on the right side of the map are more related to reporting and comparison, and on the left are those that help identify areas for improvement and guide personnel.

8.4 Possibilities for further research

This study had some limitations that serve possibilities for further research. Further research is needed to validate the connections between proposed indicators and the factors on the safety performance map. It could be examined more extensively, which are the key factors affecting safety performance currently not measured in companies. Also, the causal relations proposed on the safety performance need further research and closer examination to ensure the relationships.

The implementation and usage of measures, which both are vital phases of the performance measurement systems development, are out of the scope of this research and thus excluded. The proposed indicators should be further developed to be described by a calculating formula. Also, the usefulness or practicality of the proposed indicators has not been assessed on a more detailed level than the discussion with the food industry company. Therefore, in the future, the usefulness of the proposed measures and their suitability for measuring addressed factors needs to be studied in more detail at a practical level.

This study applies two-dimension information visualization to present safety management information in the form of a safety performance map. The benefits of visualization in management have already been identified, but as a research area, it is still relatively

new and small (Eppler and Bresciani 2013; Al-Kassab et al. 2014). In visualization, however, the possibilities seem to be almost limitless. It would be interesting to deepen the understanding of visualization and produce practical applications to support safety management in the future. For example, combining visualization and information technology could be explored.

The theme of safety culture did not receive significant attention in this study, although the theme was identified to be a core area of corporate interest. Measuring culture was perceived as challenging in the participating companies, and even in this study, it was not possible to comprehensively provide indicators for measuring culture. However, based on the comparison of the literature and the empirical findings of this research, it seems that culture or possibly safety climate, as illustrated in the safety performance map, is a concept that overlaps the presented perspectives on safety. Considering that, it needs to be studied whether measuring other factors, such as communication or training, could indicate the success or maturity of safety culture in an organization.

REFERENCES

Aaltonen, M. & Söderqvist, A. (1988). Costs of accidents in the furniture industry - A Nordic study. Scandinavian journal of work, environment & health, 14(1), pp. 103–104.

Aho, M. 2011. Konstruktio suorituskyvyn johtamisen kypsyyden arviointiin. Väitöskirja. Tampere: Tampereen teknillinen yliopisto.

Aksorn, T., & Hadikusomo, B. H. (2008). Critical success factors influencing safety program performance in Thai construction projects. Safety Science, 46 (4), pp. 709-727.

Al-Kassab, J., Ouertani, Z.M., Schiuma, G., Neely, A. (2014). Information visualization to support management decisions. International Journal of Information Technology and Decision Making, 13 (2), pp. 497-428.

Amir-Heidari, P., Maknoon, R., Taheri, B., & Bazyari, M. (2017). A new framework for HSE performance measurement and monitoring. Safety Science, 100, pp. 157–167.

Arocena, P. & Núñez, I. (2010) An empirical analysis of the effectiveness of occupational health and safety management systems in SMEs. International Small Business Journal, 28 (4), pp. 398–419.

Baxter, P & Jack, S. (2008). Qualitative Case Study Methodology: Study design and implementation for novice
researchers, in The Qualitative Report, 13(4), pp. 544-559.

Bergh, L.I., Hinna, S., Leka, S., & Jain, A. (2014). Developing a performance indicator for psychosocial risk in the oil and gas industry. Safety Science, 62, pp. 98-106.

Bititci, U. S., Ackermann, F., Ates, A., Davies, J., Garengo, P., Gibb, S., MacBryde, J., Mackay, D., Maguire, C., van der Meer, R., Shafti, F., Bourne, M. & Firat, S. U. (2011). Managerial processes: business process that sustain performance, International Journal of Operations & Production Management, 31(8), pp. 851–891.

Blair, E. (2003). Culture & leadership: Seven key points for improved safety performance. Professional Safety, 48 (6), pp. 18-22.

Blair, E., & O'Toole, M. (2010). Leading measures: Enhancing safety climate and driving safety performance. Professional Safety, 55(08), pp. 29-34.

Boumans, M. (2007). Measurement in economics: A handbook. Elsevier, London.

Bourne, M., Kennerley, M. & Franco-Santos, M. (2005). Managing through measures: a study of impact on performance. Journal of Manufacturing Technology Management, 16(4), pp. 373-395.

Bourne, M., Mills, J., Wilcox, M., Neely, A., & Platts, K. (2000). Designing, implementing and updating performance measurement systems. International journal of operations & production management, 20 (7), pp. 754–771.

BS 18004:2008. Guide to achieving effective health and safety performance. British Standards Institution, 142 p.

Burke, M.J., Sarpy, S.A., Tesluk, P.E., & Smith-Crowe, K. (2002). General safety performance: a test of a grounded theoretical model. Personnel Psychology, 55, pp. 429– 457.

Cadieux, J., Roy, M., & Desmarais, L. (2006). A preliminary validation of a new measure of occupational health and safety. Journal of Safety Research, 37(4), pp. 413–419.

Cagno, E., Micheli, G., & Perotti, S. (2011). Identification of OHS-related factors and interactions among those and OHS performance in SMEs. Safety Science, 49(2), pp. 216–225.

Christian, M. S., Bradley, J.C., Wallace, J. C., & Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors. Journal of Applied Psychology, 94(5), pp. 1103-1127.

Cocca, P., & Alberti, M. (2010). A framework to assess performance measurement systems in SMEs. International journal of Productivity and Performance Management, 59(2), pp. 186-220.

Confederation of Finnish Industries (EK). (2016). Online. Available at: https://ek.fi/wp-content/uploads/yritysturvallisuus_2016.pdf. (Accessed 13.3.2020).

Cooper, M.D. & Phillips, R.A. (2004). Exploratory analysis of the safety climate and safety behavior relationship. Journal of Safety Research, 35(5), pp. 497-512.

Cousins, P.D., Lawson, B. and Squire, B., 2008, Performance measurement in strategic buyer-supplier relationships: the mediating role of socialization mechanisms, International Journal of Operations & Production Management, 28(3), pp. 238-258.

Dyreborg, J. (2009). The causal relation between lead and lag indicators. Safety Science, 47(4), pp. 474–475.

Emory, C. (1985). Business research methods (3. p.). Homewood, Ill: Irwin.

Eppler, M. J. & Bresciani, S. (2013) Visualization in management: From communication to collaboration. A response to Zhang. Journal of Visual Languages and Computing, 24 (2), pp. 146–149.

EU-OSHA (European Agency for Safety and Health at Work). (2011). Occupational health and safety culture assessment – a review of main approaches and selected tools. Available online http://europa.eu. Accessed on 30 March 2020.

Fernández-Muñiz, B., Montes-Peón, J., & Vázquez-Ordás, C. (2007). Safety culture: Analysis of the causal relationships between its key dimensions. Journal of Safety Research, 38(6), pp. 627–641.

Fernández-Muñiz, B., Montes-Peón, J. M. & Vázquez-Ordás, C. J. (2009). Relation between occupational safety management and firm performance. Safety Science, 47, pp. 980-991.

Frick, K. (2013). Work Environment Dialogue in a Swedish Municipality — Strengths and Limits of the Nordic Work Environment Model. Nordic Journal of Working Life Studies, 3(1), pp. 69-93

Frick, K. & Wren, J. (2000). Reviewing Occupational Health and Safety Management-Multiple Roots, Diverse Perspectives and Ambiguous Outcomes. In: K. Frick, P. Jensen,

Fryer, K., Antony, J. & Ogden, S. (2009), Performance management in the public sector. International Journal of Public Sector Management, Vol. 22, No. 6, pp. 478-498.

Gavious, A., Mizrahi, S., Shani, Y. & Minchuck, Y. (2009). The costs of industrial accidents for the organization: Developing methods and tools for evaluation and cost–benefit analysis of investment in safety. Journal of Loss Prevention in the Process Industries, 22(4), pp. 434-438.

Givehchi, S., Hemmativaghef, E., & Hoveidi, H. (2017). Association between safety leading indicators and safety climate levels. Journal of Safety Research, 62, pp. 23–32.

Gordon, R., Kirwan, B., & Perrin, E. (2007). Measuring safety culture in a research and development centre: A comparison of two methods in the Air Traffic Management domain. Safety Science, 45(6), pp. 669–695.

Grabowski, M., Ayyalasomayajula, P., Merrick, J., & Mccafferty, D. (2007). Accident precursors and safety nets: leading indicators of tanker operations safety. Maritime Policy & Management, 34(5), pp. 405–425.

Griffin, M. & Curcuruto, M. (2016). Safety Climate in Organizations. Annual Review of Organizational Psychology and Organizational Behavior, 3 (3), pp. 91–212.

Gunduz, M. & Laitinen, H. (2017) A 10-step safety management framework for construction small and medium-sized enterprises, International Journal of Occupational Safety and Ergonomics, 23(3), pp. 353-359.

Haas, E., & Yorio, P. (2016). Exploring the state of health and safety management system performance measurement in mining organizations. Safety Science, 83, pp. 48–58.

Hale, A. (2003). Safety management in production. Human Factors and Ergonomics in Manufacturing & Service Industries, 13(3), pp. 185–201.

Hale, A. (2009). Why safety performance indicators? Safety Science, 47, pp. 479-480.

Hale, A., Guldenmund, F., van Loenhout, P., & Oh, J. (2010). Evaluating safety management and culture interventions to improve safety: Effective intervention strategies. Safety Science, 48 (8), pp. 1026–1035.

Hallowell, M., Hinze, J., Baud, K., & Wehle, A. (2013). Proactive Construction Safety Control: Measuring, Monitoring, and Responding to Safety Leading Indicators. Journal of Construction Engineering and Management, 139(10), pp. 04013010-1–04013010-8.

Hannula, M. (1999), Expedient Total Productivity Measurement, Acta Polytechnica Scandinavica, Industrial Management and Business Administration Series, No. 1.

Hannula, M. & Lönnqvist, A. (2002). Suorituskyvyn mittauksen käsitteet = Concepts of performance measurement. Helsinki: Metalliteollisuuden kustannus.

Haslam, C., O'Hara, J., Kazi, A., Twumasi, R. & Haslam, R. (2016). Proactive occupational safety and health management: promoting good health and good business. Safety Science, 81, pp. 99-108.

Hinze, J., Thurman, S., & Wehle, A. (2013). Leading indicators of construction safety performance. Safety Science, 51(1), pp. 23–28.

Hwang, M., & Lin, J. (1999). Information dimension, information overload and decision quality. Journal of Information Science, 25(3), pp. 213–218.

ISSA - International Social Security Association. (2020). Proactive Leading Indicators: A guide to measure and manage safety, health and wellbeing at work. ISSA, Geneva, Switzerland. 47 p.

ISO/IEC 2004. Guide 2: Standadization and related activities – General vocabulary. International Organization for Standardization, Geneva, Switzerland, 60p.

Jallon, R., Imbeau, D. & de Marcellis-Warin, N. (2011). Development of an indirect-cost calculation model suitable for workplace use. Journal of Safety Research, 42, pp. 149–164.

Janackovic, G., Stojiljkovic, E., & Grozdanovic, M. (2020). Selection of key indicators for the improvement of occupational safety system in electricity distribution companies. Safety Science, 125, 103654.

Jääskeläinen, A. (2010). Productivity measurement and management in large public service organizations. Doctor of science in technology thesis, Tampere University of Technology. 102 p.

Jääskeläinen, A., Laihonen, H., Lönnqvist, A., Pekkola, S., Sillanpää, V. & Ukko, J., 2013, Tampere: Tampereen Teknillinen Yliopisto. Tiedonhallinnan ja logistiikan laitos. 67 p.

Jääskeläinen, A. & Roitto, J-M. (2016). Visualization techniques supporting performance measurement system development. Measuring Business Excellence, 20(2), pp. 13-25.

Kaassis, B., & Badri, A. (2018). Development of a preliminary model for evaluating occupational health and safety risk management maturity in small and medium-sized enterprises. Safety, 4(1), p. 5.

Kaplan, R. S. & Norton, D. P. (2004). The strategy map: guide to aligning intangible assets. Strategy & Leadership, 32 (5), pp. 10–17.

Koivupalo, M. (2019). Health and safety management in a global steel company and in shared workplaces: case description and development needs. Doctor of science in technology thesis, University of Oulu.

Koivupalo, M. & Reiman, A. (2017). Health and safety performance indicators in global steel company. Safety Science Monitor, 20(2).

Köper, B., Möller, K. & Zwetsloot, G. (2009). The occupational safety and health scorecard – a business case example for strategic management. Scandinavian Journal of Work, Environment & Health, 35, pp. 413-420.

Laitinen, E.K. (1989). Yrityksen talouden mittarit. 2nd Edn, Weilin+Göös, Jyväskylä.

Lemieux-Charles, L., McGuire, W., Champagne, F., Barnsley, J., Cole, D. & Sicotee, C. (2003). The use of multilevel performance indicators in managing performance in health care organizations. Management Decision, Vol. 41 No. 8, pp. 760-70.

Lengler, R. & Eppler, M. (2007). Towards a periodic table of visualization methods for management. Proceedings of the Conference on Graphics and Visualization in Engineering (GVE 2007), Clearwater, FL. Available at: www.visual-literacy.org/periodic_table/periodic_table.pdf. Accessed on 20 March 2020.

Leveson, N. (2015). A systems approach to risk management through leading safety indicators. Reliability Engineering & System Safety, 136, pp. 17–34.

Lin, J., & Mills, A. (2001). Measuring the occupational health and safety performance of construction companies in Australia. Facilities, 19(3/4), pp. 131–139.

Lingard, H., Wakefield, R., & Cashin, P. (2011). The development and testing of a hierarchical measure of project OHS performance. Engineering, Construction and Architectural Management, 18(1), pp. 30–49.

Lingard, H., Hallowell, M., Salas, R., & Pirzadeh, P. (2017). Leading or lagging? Temporal analysis of safety indicators on a large infrastructure construction project. Safety Science, 91, pp. 206–220.

Linhard, J. B. (2005). Understanding the return on health, safety and environmental investments. Journal of Safety Research, 36(3), pp. 257-260.

Liu, Y-J., Chen, J-L., Cheng, S-Y., Hsu, M-T. & Wang, C-H. (2014). Evaluation of Safety Performance in Process Industries. Process Safety Progress, 33 (2), pp. 166–171.

Lu, C.S. & Yang, C.S. (2010). Safety leadership and safety behavior in container terminal operations. Safety Science, 48(2), pp. 123-134.

Lutchman, C., Maharaj, R., & Ghanem, W. (2016). Safety Management (1st ed.). CRC Press.

Lönnqvist, A. (2004). Measurement of intangible success factors: case studies on the design, implementation and use of measures. Doctoral dissertation 475, Tampere University of Technology, Tampere.

Lönnqvist, A., Kujansivu, P. & Antikainen, R. (2006). Suorituskyvyn mittaaminen. Tunnusluvut asiantuntijaorganisaation johtamisvälineenä. Edita.

Mayhew, C., Quinlan, M., Ferris, R., & Mayhew, C. (1997). The effects of subcontracting/outsourcing on occupational health and safety: Survey evidence from four Australian industries. Safety Science, 25(1-3), pp. 163–178.

Mearns, K., Whitaker, S.M., & Flin, R. (2003). Safety climate, safety management practice and safety performance in offshore environments. Safety Science, 41(8), pp. 641-680.

Mearns, K. & Yule, S. (2009). The role of national culture in determining safety performance.: challenges for the global oil and gas industry. Safety Science, 47(6), pp. 777-785.

Meyer, M. W. (2002). Rethinking performance measurement beyond the balanced scorecard. Cambridge, UK; Cambridge University Press.

Mohammadfam, I., Kamalinia, M., Momeni, M., Golmohammadi, R., Hamidi, Y., & Soltanian, A. (2017). Evaluation of the Quality of Occupational Health and Safety Management Systems Based on Key Performance Indicators in Certified Organizations. Safety and Health at Work, 8(2), pp. 156–161.

Mossink, J. & De Greef, M. (2002). Inventory of socioeconomic costs of work accidents. Luxembourg: European Agency for Safety and Health at Work.

Neal, A., Griffin, M. A. & Hart, P. M. (2000). The impact of organizational climate on safety climate and individual behavior. Safety Science, 34(1-3), pp. 99-109.

Neal, A. & Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. Journal of Applied Psychology, 91(4), pp. 946-953.

Neely, A. (1998). Measuring Business Performance. Why, What and How? Profile Books Ltd, London.

Neely, A., Richards, H., Mills, J., Platts, K., & Bourne, M. (1997). Designing performance measures: a structured approach. International Journal of Operations & Production Management, 17(11), pp. 1131–1152.

Neubert, M., Hunter, E., & Tolentino, R. (2016). A servant leader and their stakeholders: When does organizational structure enhance a leader's influence? The Leadership Quarterly, 27(6), pp. 896–910.

Ostrom, C., Wilhelmsen, O.C. & Kaplan, B. (1993). Assessing safety culture. Nuclear Safety, 65, pp. 163-172.

Petty, R., & Guthrie, J. (2000). Intellectual capital literature review. Journal of Intellectual Capital, 1(2), pp. 155–176.

Podgórski, D. (2015). Measuring operational performance of OSH management system – A demonstration of AHP-based selection of leading key performance indicators. Safety Science, 73, pp. 146–166.

Radnor, Z. J. & Barnes, D. (2007). Historical analysis of performance measurement and management in operations management. International Journal of Productivity and Performance Management, 56 (5/6), pp. 384–396.

Reiman, T. & Pietikäinen, E. (2010). Indicators of safety culture – selection and utilization of leading safety performance indicators. Swedish Radiation Safety Authority, Research Report 2010:07.

Reiman, T. & Pietikäinen, E. (2012). Leading indicators of system safety - Monitoring and driving the organizational safety potential. Safety Science,45(3), pp. 329-353.

Rompho, N. (2012) An experiment in the usefulness of a strategy map. Measuring Business Excellence, 16 (2), pp. 55–69.

Rundmo, T. & Hale, A.R. (2003). Managers' attitudes towards safety and accident prevention. Safety Science, 41, pp. 557–574.

Saunders, M., Lewis, P. & Thornhill, A. (2009). Research methods for Business Students, 5th edition. Prentice Hall.

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research methods for business students, 8th edition. Pearson Education.

SFS-ISO 45001:2018. Occupational health and safety management systems - Requirements with guidance for use. Finnish Standards Association, Helsinki, Finland, 47 p.

Sheehan, C., Donohue, R., Shea, T., Cooper, B., & Cieri, H. (2016). Leading and lagging indicators of occupational health and safety: The moderating role of safety leadership. Accident Analysis and Prevention, 92, pp. 130–138.

Sievänen, M., Nenonen, N. & Hämäläinen, P. (2013). Economic impacts of occupational health and safety interventions – A critical analysis based on the nine-box model of profitability. Proceedings of the 45th Nordic Ergonomics & Human Factors Society Conference NES2013.

Simons, R., Dávila, A. & Kaplan, R. S. (2000). Performance measurement & control systems for implementing strategy. Upper Saddle River (N.J.): Prentice Hall.

Sinelnikov, S., Inouye, J. & Kerper, S. (2015). Using leading indicators to measure occupational health and safety performance. Safety Science, 72, pp. 240-248.

Swuste, P., Theunissen, J., Schmitz, P., Reniers, G., & Blokland, P. (2016). Process safety indicators, a review of literature. Journal of Loss Prevention in the Process Industries, 40, pp. 162–173.

Tappin, D., Bentley, T., & Ashby, L. (2015). An implementation evaluation of a qualitative culture assessment tool. Applied Ergonomics, 47, pp. 84–92.

Tappura, S., Hämäläinen, P., Saarela, K. L. & Luukkonen, O. (2010). Mittaaminen osana työturvallisuuden johtamista. Työturvallisuuskeskus. 27 p.

Tappura, S. (2017). The management of occupational health and safety. Doctor of science in technology thesis, Tampere University of Technology.

Tappura, S., Sievänen, M., Heikkilä, J., Jussila, A. & Nenonen, N. (2015). A management accounting perspective on safety. Safety Science 71, pp. 151-159.

Tarrants, W. (1980). The measurement of safety performance. Garland STPM Press.

Taylor, J. (2010). Safety culture assessing and changing the behavior of organisations. Farnham, England: Gower.

Tegarden, D.P. (1999). Business information visualization. Communications of the AIS, 1, pp. 1-38.

Tremblay, A. & Badri, A. (2018). Assessment of occupational health and safety performance evaluation tools: State of the art and challenges for small and medium-sized enterprises. Safety Science, 101, pp. 260–267.

Tsao, M., Hsieh, C., & Chen, L. (2017). The role of management commitment and employee involvement in safety management. International Journal of Organizational Innovation,10(2), pp. 52–74.

Tung, A., Baird, K., & Schoch, H. (2011). Factors influencing the effectiveness of performance measurement systems. International Journal of Operations & Production Management, 31(12), pp. 1287–1310.

van Dooren, W., Bouckaert, G. & Halligan, J. (2015). Performance management in the public sector (2nd ed.). Abingdon: Routledge.

Veltri, A. & Pagell, M., Behm, M. & Das, A. (2007). A data-based evaluation of the relationship between occupational safety and operating performance. Journal of SH&E Research. 4.

Vredenburgh, A. G. (2002). Organizational safety: which management practices are most effective in reducing employee injury rates? Journal of Safety Research, 33(2), pp. 259-276.

Wreathall, J. (2009). Leading? Lagging? Whatever! Safety Science 47, pp. 493-494.

Wu, T.C., Chen, C.H., & Li, C. C. (2008). A correlation among safety leadership, safety climate and safety performance. Journal of Loss Prevention in the Process Industries, 21(3), pp. 307-318.

Yin, R. (2003). Case study research: design and methods (3. ed.). Sage.

Yukl, G. (2010). Leadership in organizations (7th ed.). Pearson Prentice Hall.

Zhang, K. (2012). Using visual languages in management. Journal of Visual Languages and Computing, 23 (6), pp. 340–343.

Zohar, D. (2002). The effects of leadership dimensions, safety climate, and assigned priorities on minor injuries in work groups. Journal of Organisational Behavior, 23, pp. 75–92.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. Accident Analysis & Prevention, 42(5), pp. 1517–1522.

Zwetsloot, G., van Scheppingen, A., Dijkman, A., Heinrich, J., & den Besten, H. (2010). The organizational benefits of investing in workplace health. International Journal of Workplace Health Management, 3(2), pp. 143–159.

Zwetsloot, G., Leka, S., Kines, P., & Jain, A. (2020). Vision zero: Developing proactive leading indicators for safety, health and wellbeing at work. Safety Science, 130, pp. 104890–.

APPENDIX A: INTERVIEW STRUCTURE 1

Creation of the safety performance map, group interviews with the case companies, summer and autumn 2019.

- Examination of the overall framework
- Open discussion on the perspectives of the framework:
    - How do these perspectives occur in your workplace/company? What sub-dimensions do you identify?
    - What is the role of these perspectives in the safety performance of your workplace/company?
- Detailed examination individual perspectives supported by more detailed definitions:
    - Do you identify still some other relevant aspects for safety performance in your workplace/company?
- Prioritization of the identified building blocks of safety performance (max 3-5 points per one perspective):
    - Discussion on the links between the prioritized aspects
- Linking your existing safety performance measures to the created map:
    - Identification of possible development needs in measurement

APPENDIX B: INTERVIEW STRUCTURE 2

Testing the safety performance map, group interviews with the case companies' representatives and the experts' panel, winter 2020

Questions for the companies' representatives:

- Do you recognize the factors presented in the map in your organization?
- Do you identify any missing elements?
- Are the titles descriptive or is there a need for specifying them?
- What do you think about the represented causal relations on the map?

Questions for the expert's panel:

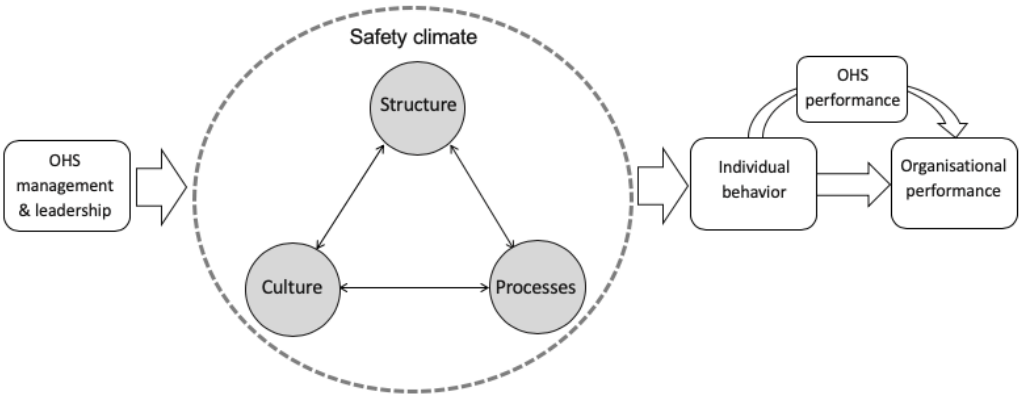
- How industry-specific the presented model is? Is the map suitable for other industries than the ones involved in the creation process?
- How generalizable is the model? Possibly, what kind of context is missing from these findings?
- Is the model in relation to theory? Does it correspond to theoretical concepts?

APPENDIX C: INTERVIEW STRUCTURE 3

Validation of the map, interviews with the companies involved in the testing phase of the map, spring 2020.

Opening questions:

- Identify the five (5) most important factors for safety, i.e. the building blocks of safety performance at your company. These are the factors that need to be in place in order to meet your safety requirements. (i.e. basic safety requirements)
- Next, name five (5) safety-related issues that are currently the focus of attention or development in your company, or which you see becoming more important in the future.
- In what areas would you place the 10 factors you identified?



The interaction between OHS M&L, organisation's structure, culture and processes to generate the desired level of OHS & organisational performance (modified from Guldenmund 2010, Tappura et al. 2015, Wu et al. 2009, Yukl 2010)

Detailed examination of the map section by section:

- Do you recognize the themes presented in the map in your organization? Describe with examples how these factors occur in your workplace or company.
- Are some themes more conventional - ones that have been on the agenda for a long time?
- Are there themes that are topical or interesting in the future?
- Do you find something less important or relevant to you?
- Do you identify any missing elements? Elements, that are not in the map, but should be there.
- Are the titles descriptive or is there a need for specifying them?

- What do you think about the represented causal relations on the map?
- Is there something else you would like to add?

APPENDIX D: SAFETY PERFORMANCE INDICATORS IN THE LITERATURE

Reference	Method and context	Objective	Results	No. of indicators	Lead	Lag
Köper et al. 2009	Empirical. A case study at a German automobile manufacturer.	Conceptualize a method by which qualitative factors contribute to a company's performance.	The Balanced Scorecard is a suitable means to control OSH issues. Employee health-related issues are interconnected with performance factors.	6	X	
Hale et al. 2010	Empirical. A case study in 29 companies.	Describe the interventions distinguishing successful and unsuccessful projects.	Interventions bringing constructive dialogue, providing motivation to line managers and strengthening the monitoring distinguish the most the successful and less successful projects.	12	X	X
Reiman and Pietikäinen 2010	Safety-critical organizations, emphasis on the nuclear industry.	Provide an overview on leading safety indicators in the domain of nuclear safety.	Proposes the use of safety culture as a leading safety performance indicator and offers an example list of potential safety indicators in three indicator categories.	235	X	X
Reiman and Pietikäinen 2012	Review.	Describe the purposes, types and the role of safety indicators in evaluating and improving organizations' safe functioning.	A theoretical framework for choosing indicators. Indicators divided into outcome (lag), monitor (lead) and drive (lead) indicators. Emphasis the importance of leading indicators.	77	X	X
Hallowell et al. 2013	Empirical. A mixed-methods research approach in	Define lead indicators; describe resources, and	Presents 13 leading indicators and an action plan	13	X	

	the construction sector.	management actions needed if an indicator does not meet the desired value.	for responding when company tolerance levels are not met.		
Hinze et al. 2013	Empirical study of safety management practices in the construction sector.	Offer suggestions on the selection and use of effective leading indicators.	Leading indicators categorized into active and passive measures. Each selected measure should reflect the performance of different entities, e.g. the workers, or supervisors.	13	X
Bergh et al. 2014	Empirical study in a Norwegian oil and gas company.	Develop an HSE indicator for psychosocial risk.	A new proactive indicator for psychosocial risk.	1	X
OHS best practices 2015	Review. A user guide from Government of Alberta, Jobs, Skills, Training and Labour. Canada.	Provide an overview of what leading indicators are, and how and why they might be applied.	Guidance for choosing, implementing and using a leading indicator.	12	X
Podgórski 2015	Review. The indicators are listed on the basis of a literature and author's experience.	Demonstrate the application of a method for prioritization and selection of leading indicators.	The paper presents a concept of making use of operationally focused minimum set of key performance indicators assigned to individual OSH MS components.	109	X
Sinelnikov et al. 2015	Empirical. A multi-industry survey.	Describe OHS experts' understanding of lead indicators; explore practices in processing the data from indicators; and identify	Does not recommend the indicators itself. Findings suggest several important characteristics (e.g. actionability) that describe effective leading indicators and describe modifiable factors (e.g., commit-	0	X

		barriers and enablers for lead indicators.	ment) that may be correlated with such characteristics.			
Sheehan et al. 2016	Empirical. A national multi-industry survey conducted in Australia.	Consider the association between leading and lagging indicators and investigate the effect of safety leadership on this association.	The results confirm an association between leading and lagging indicators and the moderating impact of middle management safety leadership on this dual relationship. The findings encourage emphasizing leading indicators.	23	X	X
Swuste et al. 2016	Review. Process safety related.	Investigate process safety indicators in the scientific and professional literature.	The definitions for process safety indicators vary in the literature. Questions the distinction between lead and lag indicators and the quantification of indicators.	50	X	X
Amir-Heidari et al. 2014, as cited in Amir-Heidari et al. 2017	Empirical. Review and a case study in three drilling companies.	Review and classify KPIs based on time, scope and type. Analyze data of KPIs in the case companies.	22 KPIs identified for the drilling sector in Iran. A new framework for HSE performance measurement.	22	X	X
Givehchi et al. 2017	Empirical. Nordic Occupational Safety Climate Questionnaire (NOSACQ-50) conducted in Iran.	Evaluate the association of lead indicators for safety inspections and non-compliances, with safety climate levels.	Findings suggest that safety non-compliances detected as a result of conducting safety inspections could be used to monitor the safety climate state.	4	X	
Koivupalo and Reiman 2017	Empirical. A case study in a global steel company.	Describe local OHS measurement practices and the concepts of leading	There are differences in terminology within different organizations. A need	11	X	X

		and lagging indicators.	for standard index that allows benchmarking was identified.			
Lingard et al. 2017	Empirical. Temporal analysis on an infrastructure construction project in Australia.	Uncover time dependent relationships and explore causal relationships between indicators.	Leading indicators can behave as both lead and lag indicators in relation to the TRIFR. There is a cyclical relationship between safety management actions and the rate of safety incidents.	15	X	(X)*
Mohammadfam et al. 2017	Empirical. A comparison in three certified and three non-certified companies in Iran representing design and construction of power, oil, and gas facilities.	Develop appropriate criteria and indicators for OHSMSs; and compare OHSMSs performance criteria in different organizations.	A set of criteria and related indicators developed for five OHS activities. Findings indicate that the performance of certified companies with respect to OHS management practices is significantly better than that of noncertified companies.	43	X	
Janackovic et al. 2020	Empirical. A case study in the electricity distribution company in Serbia.	Determine the significance of certain occupational safety indicators, and to rank them.	Presents occupational safety indicators, and a method for the selecting and ranking of indicators based on expert assessment and group fuzzy analytic hierarchy process.	48	X	
Zwetsloot et al. 2020	Empirical. 5 ISSA sections involved in: electricity, information for prevention, mining, transport and trade.	Describe the development process of proactive leading indicators for safety, health and well-being (SHW) at work.	14 indicators that serve as both qualitative and quantitive measures developed to complement the ISSA Vision Zero strategy, two in relation to each 7 golden rules for promoting SHW.	14	X	

*Some indicators may serve as both leading and lagging indicators.