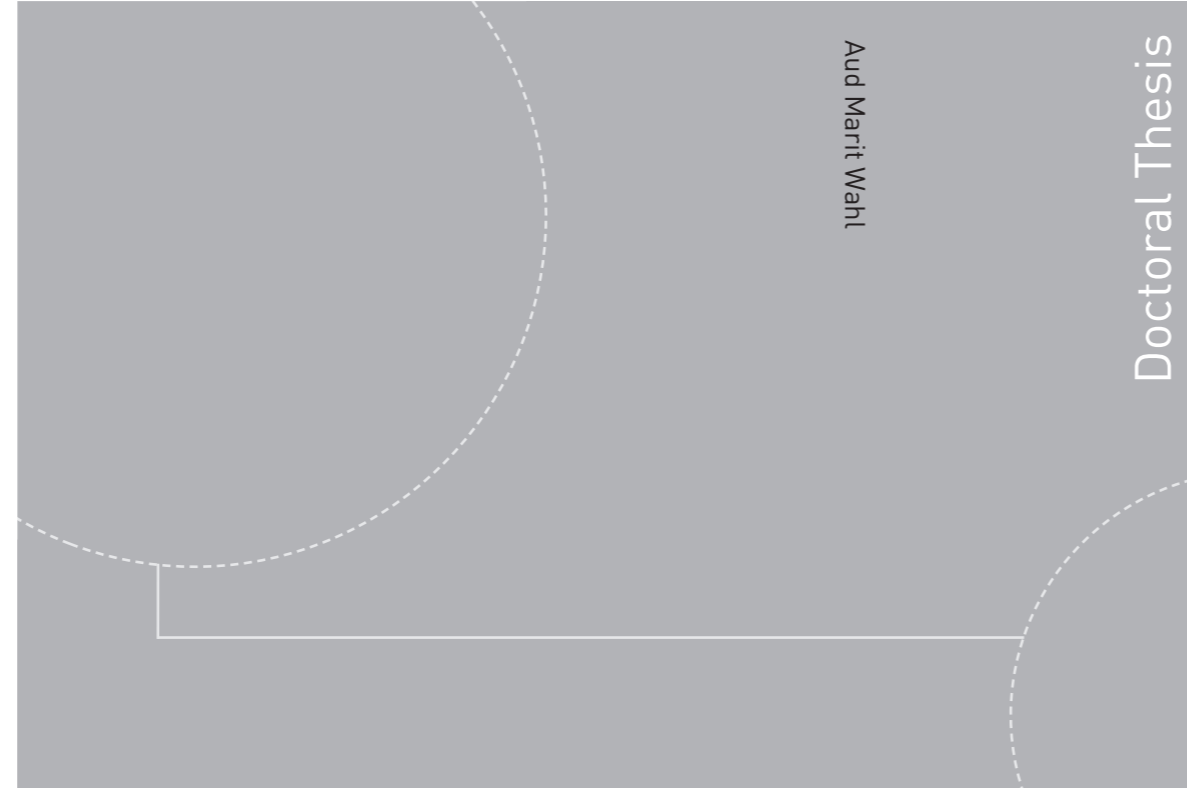


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Aud Marit Wahl

**Maritime safety leadership and
simulator-based training**

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Maritime safety leadership and simulator-based training

Thesis for the degree of Philosophiae Doctor

Trondheim, November 2019

Norwegian University of Science and Technology
Faculty of Economics and Management
Department of Industrial Economics and Technology Management



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Photo: Kristian Topp. Copyright Kongsberg Group

Abstract

Ship officers hold a central role in maintaining safe and efficient operations at sea. The purpose of this thesis is to contribute to the understanding of maritime safety leadership and explore how bridge simulators can be used to train deck officers. This is investigated through a qualitative study answering four research questions:

1. How is safety leadership understood in a maritime context?
2. What leadership skills do maritime officers need, and how can these be trained?
3. What is the significance of social factors in the simulator-based training of professional deck officers?
4. How is the simulator-based training of deck officers used to manage performance variability and safety at sea?

The dissertation contains four different but interlinked scientific works addressing each specific research question in addition to contributing to an overall understanding of the social processes involved in maritime safety leadership and the training of deck officers. The empirical material is collected in two main bulks. The leadership context is investigated by spending 33 days at three oil tankers and by interviewing 50 crew members at these ships. Maritime training practices are investigated by observing 13 simulator-based courses for deck officers and by interviewing 12 instructors and 29 course participants.

The work uncovers that safety leadership in a maritime context can be described as a balancing act and demonstrates how maritime officers must adjust their leadership to both informal factors and formal requirements to run the ship in an efficient and safe manner. Six safety leadership skills are proposed – *situation awareness, decision making, communication, team coordination, assertiveness, and adaptability*. The last skill category relates to resilience skills and the ability to manage performance variability. The thesis coins the terms *social fidelity* to bridge the gap between computer technology and collaborative learning activities pointing to the importance of social processes in simulator-based training. The study demonstrates that realistic training should not only focus on adverse events and emergency handling but must also include mundane tasks and minor deviations so that operators can learn to catch and contain errors before they evolve into uncontrollable situations.

List of papers

This thesis contains four independent papers – one book chapter and three journal articles. These are the basis of the work, and each paper relates to one specific research question. Together, they aim to contribute to develop the concept of safety leadership and deepen the understanding of how to train maritime officers in different aspects of the leader role. The dissertation synthesises and reflects on these four scientific works.

Paper 1 (Wahl, A. M., and Kongsvik, T. 2017)

Fra helt til mellomleder: Hverdagsledelse til sjøs.

Published in: *Heldal, Antonsen, and Kvalheim (eds.). Sikkerhet og ledelse. Oslo: Gyldendal Akademiske, 171–193.*

Paper 2 (Wahl, A. M, and Kongsvik, T. 2018)

Crew resource management training in the maritime industry: A literature review.

Published in: *WMU Journal of Maritime Affairs, 17(3), 377–396.*

<https://doi.org/10.1007/s13437-018-0150-7>

Paper 3 (Wahl, A. M. 2019)

Expanding the concept of simulator fidelity: The use of technology and collaborative activities in training maritime officers.

Published in: *Cognition, Technology & Work.* <https://doi.org/10.1007/s10111-019-00549-4>

Paper 4 (Wahl, A. M., Kongsvik, T., and Antonsen, S. 2019)

Balancing Safety I and Safety II: Learning to manage performance variability at sea using simulator-based training.

Submitted to: *Reliability Engineering & System Safety, 3 March 2019. In review process.*

Contents

- 1 Introduction 1**
- 1.1 Structure of the thesis 5
- 2 Research context: The oil tanker industry 9**
- 2.1 Life on board shuttle tankers 9
 - 2.1.1 Crew and officers..... 9
 - 2.1.2 Offloading operations and DP technology 12
 - 2.1.3 Ship management..... 14
- 2.2 Certification and simulator-based training of deck officers 16
- 3 Theoretical framework 19**
- 3.1 Safety 19
 - 3.1.1 Safety as the absence of risk..... 19
 - 3.1.2 Safety as the presence of desirable organisational factors..... 20
 - 3.1.3 Safety as adaptability..... 22
- 3.2 Leadership..... 23
 - 3.2.1 Leadership as transformational and transactional..... 25
 - 3.2.2 Leadership skills in high-risk work settings 27
 - 3.2.3 Leadership as social construction processes..... 30
- 3.3 Simulator-based training and learning processes..... 31
 - 3.3.1 Simulator fidelity..... 32
 - 3.3.2 Training professionals 33
 - 3.3.3 Crew resource management..... 35
- 3.4 Safety leadership training 37
- 4 Methodology 41**
- 4.1 The researcher role and research ethics 41
- 4.2 Research strategy and design 43
- 4.3 Data collection 45

4.3.1	Observations	46
4.3.2	Interviews	47
4.3.3	Supplementary data	48
4.4	Analysis	49
4.5	Research quality	50
5	Overview of results	53
5.1	Balancing leadership styles.....	53
5.2	Maritime officers' essential leadership skills	54
5.3	Social fidelity in simulator-based training.....	56
5.4	Training to manage safety and performance variability	57
6	Discussion	59
6.1	Safety leadership as a balancing act.....	59
6.2	Adaptability as a safety leadership skill.....	64
6.3	Social fidelity as a training tool	67
7	Contributions, implications, and further research.....	69
8	References.....	73
9	Appendix	83
9.1	Notification Norwegian Centre for Research Data.....	84
9.2	Interview guides.....	86
9.3	The papers.....	88

Overview figures, tables, and pictures

- Figure 1 Organisational hierarchy and roles at a tanker..... 11
- Figure 2 Layout and design of an advanced bridge simulator. 16
- Figure 3 Main elements in simulator-based training..... 18
- Figure 4 Non-technical skills taxonomy used to observe and assess pilots. 36
- Figure 5 Typology social science research..... 44
- Figure 6 Safety leadership: Balancing formal safety requirements and informal factors..... 60
- Figure 7 Technical skills as the basis for safety leadership. 67

- Table 1 Overview research questions, data sources, and scientific works..... 6
- Table 2 Safety-related regulations adopted by IMO 14
- Table 3 Examples of transformational, transactional, and passive leadership..... 26
- Table 4 Overview of non-technical CRM skills for pilots. 29
- Table 5 Overview of empirical material..... 46
- Table 6 Taxonomy of non-technical skills of maritime officers 55
- Table 7 Six skills essential to safety leadership 66

- Picture 1 Shuttle tanker arriving at oil terminal for discharging oil..... 7
- Picture 2 Crew at shuttle tanker operating in Brazilian waters. 10
- Picture 3 DP work station at shuttle tanker bridge..... 13
- Picture 4 Proximity to offloading unit when connected..... 15
- Picture 5 DP training in bridge simulator..... 17
- Picture 6 View from shuttle tanker bridge. 40
- Picture 8 Able-bodied seafarer. 72

Key abbreviations

CRM	Crew Resource Management
DP	Dynamic Positioning
DPO	Dynamic Positioning Operator
IMO	International Maritime Organization
ISM Code	International Safety Management Code
SOLAS	International Convention for the Life of Sea
STCW	Standards of Training, Certification, and Watchkeeping for Seafarers
KM	Kongsberg Maritime
HRO	High Reliability Organizations
RE	Resilience Engineering
TK	Teekay Shipping Company

1 INTRODUCTION

The shipping industry transports approximately 90% of global trade (AGCS¹ 2018). In 2017, 2,712 registered casualties and 94 total losses of merchant ships of over 100 gross tons worldwide were recorded (ibid.). The grounding of the cruise ship *Costa Concordia* in January 2012, where 33 people perished (MIT² 2013); the fire on board the oil tanker *Sanchi* in January 2018, with 32 fatalities (AGCS 2018); the capsizing of the frigate KNM *Helge Ingstad* at the west coast of Norway in November 2018 (AIBN³ 2019b); and the engine failure at the cruise ship *Viking Sky* in March 2019 (AIBN 2019a) exemplify the potential severity of accidents at sea. Despite a steady decline in the number of reported accidents, there is a general concern in the industry that human error continues to be a major driver of incidents in a situation where commercial pressure is increasing, vessels become larger, and the socio-technological system grows more complex (EMSA⁴ 2018; AGCS 2018).

Ship officers hold a central role in maintaining safe and efficient operations at sea. The purpose of this thesis is to contribute to the understanding of maritime safety leadership and explore how bridge simulators can be used to train professional deck officers. This is investigated through a qualitative study divided into two main bulks answering four research questions. The leadership context is investigated by spending 33 days at three oil tankers and by interviewing 50 crew members at these ships. Maritime training practices are investigated by observing 13 simulator-based courses for deck officers and by interviewing 12 instructors and 29 course participants. The following sections briefly describe each research question:

1. How is safety leadership understood in a maritime context?
2. What leadership skills do maritime officers need, and how can these be trained?
3. What is the significance of social factors in the simulator-based training of professional deck officers?
4. How is the simulator-based training of deck officers used to manage performance variability and safety at sea?

¹ Allianz Global Corporate & Speciality

² Italian Ministry of Infrastructure and Transport

³ Accident Investigation Board Norway

⁴ European Maritime Safety Agency

Ship officers are leaders at the *sharp end* (Flin et al. 2008; Salas et al. 2004) of a shipping company and are directly exposed to the dangers associated with work together with the rest of the crew. There are several officers on board a merchant ship, including four senior officers (IMO 2011). The master has the highest rank and is responsible for the safe and efficient operation of the ship; the chief mate is the officer next in rank. The chief engineer is responsible for the mechanical and electrical installations of the ship, and the first engineer is next in rank. They are responsible for the core activities and value creation of their organisation and supervise daily work on board. This may be described as *operational leadership* and defined as a process that involves influencing others in a group context to achieve certain goals in situations characterised by uncertainty and risk (Olsen and Eid 2015). The elements of uncertainty and risk are the key aspects of this kind of leadership and organisational safety the primary goal. Safety researchers have addressed the leadership role in mitigating risk indirectly through studies on the use and design of *safety management systems* (e.g. Li and Guldenmund 2018; Almklov et al. 2014; Hale and Borys 2013a, 2013b; Håvold 2010; Reiman and Oedewald 2009; Hale 2003; Rasmussen 1997). Lately, several works have made a distinction between *safety management* and *safety leadership* (Kongsvik et al. 2018; Antonsen et al. 2017; Pilbeam et al. 2016; Glendon and Clarke 2016; Conchie 2013; Clarke 2012). The term *safety leadership* ties together the formal and informal aspects of leadership. It points to the importance of coordinating and controlling work in accordance with the safety management system while, at the same time, considering social processes and psychological dimensions that may influence safe work performance (Kongsvik et al. 2018). Thus, safety leadership can be understood as a process that handles the important formal and informal functions, tasks, roles, and responsibilities when maintaining safety in an activity or an organisation (ibid.). Few empirical studies are available on the concept of safety leadership in general, and only a few exist in the maritime domain so far (Kim and Gausdal 2017; Pilbeam et al. 2016; Nielsen et al. 2016; Glendon and Clarke 2016). The first research question sets out to contribute to the understanding of safety leadership in a maritime context.

The training of maritime officers has gradually changed over the last twenty years. Seafaring skills are still developed under the supervision of senior officers in an apprenticeship regime on board vessels, but the use of onshore simulators to train and certify mariners is steadily

rising (Sellberg 2017; Ghosh et al. 2014; Gekara et al. 2011; Sampson et al. 2011; Emad and Roth 2008). The latest version of the STCW convention highlights the use of simulators for the training and certification of seafarers and requires all ship officers to undergo leadership and teamwork training to be certified or to renew their certificates (IMO 2011). This leadership training is often described as CRM and was developed as a training concept by the aviation community in the 1970s as a response to the high number of fatal accidents in the industry caused by human error. The intention was to improve flight crews' skills in areas such as situation awareness, decision making, teamwork, and leadership (Kanki et al. 2010). These skills are labelled non-technical skills and defined as 'the cognitive, social, and personal resource skills that complement technical skills and contribute to safe and efficient task performance' (Flin et al. 2008: 1). This approach to team members' learning of social and cognitive skills is usually based on psychological perspectives (e.g. Flin et al. 2016; Kanki et al. 2010; Flin et al. 2003; Helmreich et al. 1999). To broaden the scope of CRM training, this thesis sets out to supplement the prevailing psychological approach by including social processes in the inquiry. The second research question investigates what leadership skills maritime officers need and how these can be trained.

The simulator training of professional maritime officers provides a risk-free environment to learn how to handle critical or dangerous situations at sea (Chrichton 2017; Hontvedt 2015; Håvold et al. 2015; Hontvedt and Arnseth 2013). The development of simulator-based training programs has been mainly technology driven; computer technology has made it possible to build advanced simulators that may replicate almost any real-world artefact or event (Dahlstrom et al. 2009; Liu et al. 2009; Salas et al. 1998). The term *simulator fidelity* indicates how closely a simulation imitates reality (Hontvedt and Arnseth 2013; Dahlstrom et al. 2009; Alessi and Trollip 2001). It is characterised as low or high depending on how immersive or complex the simulations are perceived (Hontvedt and Arnseth 2013; Liu et al. 2009). The degree of fidelity increases as the simulated environment becomes more alike with the physical work environment (e.g. mimicking the physical layout of a ship bridge or the physical forces affecting a vessel) (Hontvedt and Arnseth 2013; Liu et al. 2009). The dominant assumption has been that high simulator fidelity corresponds to a high resemblance to the technological attributes that characterise a work environment and that such a physical

resemblance is a prerequisite for the high-quality training of professionals (Hontvedt 2015; Dahlstrom et al. 2009; Salas et al. 1998). Several studies have pointed to a need to bridge the gap between technology design and social processes in simulator-based training programs (Hontvedt 2015; Hontvedt and Arnseth 2013; Rystedt and Sjöblom 2012; Dahlstrom et al. 2009; Salas et al. 1998). Hontvedt and Arnseth (2013) analysed the social organisation of nautical instructions in a ship simulator and found that not only the technological aspects of the training environment but also the social interaction and activities among students influence training quality. Rystedt and Sjöblom (2012) demonstrated how the technical features of a simulator alone do not determine the degree of realism or relevance but rather should be regarded as a backdrop for managing lifelike problems triggered by the realistic unfolding of events. The third research question explores the significance of social processes in the simulator-based training of professional deck officers.

The overarching goal of maritime simulator-based training is to maintain operational safety at sea. Although much of the work is routine for long periods, maritime officers must be able to handle various conditions and be prepared for both the known and the unknown. The ability of complex sociotechnical systems and their actors to adapt and adjust to the situation at hand is a central aspect of safety research. Weick and Sutcliffe (2015; 2007; 2001) describe mindful attention to all deviations from normality and the ability to adapt spontaneously and flexibly in all situations as key characteristic of HROs. They use the term *resilience* to indicate an organisation's ability to return to a normal state after systemic disturbances. According to the RE perspective, resilience is a form of organisational control: 'A system is in control if it is able to minimize or eliminate unwanted variability, either in its own performance, in the environment, or in both. The fundamental characteristic of a resilient organization is that it does not lose control of what it does but is able to continue and rebound' (Hollnagel and Woods 2006: 348). According to this view, a resilient system is defined as that with an inherent capability to adjust its functioning prior to or following a disturbance and continue to work (Hollnagel et al. 2006). The expression *resilience skills* points to the ability to control variability and has been defined as 'individual or team skills of any type necessary to adjust performance . . . to maintain safe and efficient operations during both expected and unexpected situations' (Saurin et al. 2014: 30). The concept has, to a limited extent, been investigated in the safety

literature (Patriarca et al. 2018; Bergström et al. 2015; Righi et al. 2015). This thesis aims to study how resilient performance can be achieved in practice. The last research question explores how the simulator-based training of deck officers can be designed to manage performance variability and safety at sea.

1.1 STRUCTURE OF THE THESIS

This thesis aims to contribute to the understanding of maritime safety leadership and explore how bridge simulators can be used to train professional deck officers. It contains four different but interlinked scientific works that respectively answer the research questions. An overview of the papers, research questions, and main data sources is given in Table 1. The first paper describes what can be considered good leadership in a maritime context and discusses leadership in a safety perspective based on observations at three tankers and interviews with 50 crew members and officers at these ships. The second paper is a literature review that describes what non-technical skills maritime officers need to learn and how to train them. The third paper is based on the observations of seven different technical training courses for professional deck officers and 22 interviews with officers attending the training. The article coins the term *social fidelity*, explaining how social factors play a major role in simulator-based learning. The last paper demonstrates how the simulator-based training of professional deck officers can be used to manage performance variability and safety at sea. This article draws on field notes from six training courses and interviews with 12 trainers and 7 trainees.

The four papers are the core of this PhD project. The thesis presents the separate works but also intends to give an overview of the project. The work is presented and structured in six main sections. The dissertation starts by visualising the research context, emphasising the oil tanker industry and life on board the tankers. This forms the backdrop for the study. The training context and how bridge simulators are used to train professional deck officers are also described in this chapter.

Safety leadership is the core concept in this work. The theoretical framework starts by presenting different relevant perspectives from two main scientific fields: safety and leadership. The next section offers theories pertinent to the simulator-based training of deck officers. It describes the term *simulator fidelity*, presents different aspects of the training of professionals, and introduces CRM as a leadership training program. The last section

summarises the theoretical framework, defines *safety leadership*, and suggests how knowledge about social processes may be valuable to gain new insight into the simulator-based training of professionals.

Table 1 Overview research questions, data sources, and scientific works

RESEARCH QUESTION	DATA SOURCE	SCIENTIFIC WORK
1) How is safety leadership understood in a maritime context?	- Observations in tankers - Interviews with seafarers	Wahl, A. M., and Kongsvik, T. (2017). 'Fra helt til mellomleder: Hverdagsledelse til sjøs.' In Heldal, Antonsen og Kvalheim (eds.) <i>Sikkerhet og ledelse</i> . Oslo: Gyldendal Akademiske, 171–193.
2) What leadership skills do maritime officers need, and how can these be trained?	- Literature review	Wahl, A. M, and Kongsvik, T. (2018). 'Crew resource management training in the maritime industry: A literature review.' <i>WMU Journal of Maritime Affairs</i> , 17(3), 377–396.
3) What is the significance of social factors in the simulator-based training of professional deck officers?	- Observations in training centres - Interviews with deck officers	Wahl, A. M. (2019). 'Expanding the concept of simulator fidelity: The use of technology and collaborative activities in training maritime officers.' <i>Cognition, Technology & Work</i> . Online 12 March 2019.
4) How is the simulator-based training of deck officers used to manage performance variability and safety at sea?	- Observations in training centres - Interviews with simulator instructors	Wahl, A. M., Kongsvik, T., and Antonsen S. (2019). 'Balancing Safety I and Safety II: Learning to manage performance variability at sea using simulator-based training.' In review. Submitted to <i>Reliability Engineering & System Safety</i> , 3 March 2019.

The methodology of this qualitative study is explained in Chapter 4. It starts with a presentation of research ethics, transparency, and reflexivity, focusing on the author's role as a researcher, followed by an outline of the research strategy and design. The data collection process and the empirical material are accounted for in more detail in a separate section. A description of the abductive analytical approach applied is provided before the chapter ends by discussing the scientific quality of the study, emphasising credibility, transferability, dependability, and confirmability.

A summary of the research results and the four scientific works is given in Chapter 5. The discussion examines how these different works explore safety leadership at sea and how the study contributes to understanding the concept of the simulator-based training of maritime leaders. It starts by discussing safety leadership as a balancing act followed by a debate on the importance of adaptability as a skill and looks at the importance of *social fidelity* when training deck officers. The thesis concludes with a discussion on contributions, implications, and further work related to the four research questions and the overarching purpose of this study.



Photo: Aud M Wahl

Picture 1 Shuttle tanker arriving at oil terminal for discharging oil.

2 RESEARCH CONTEXT: THE OIL TANKER INDUSTRY

This chapter presents the research context. The first subchapter offers the reader an understanding of the lifeworld at tankers and this specific leadership setting. The second subchapter describes professional deck officers' training requirements and what characterises simulator-based training programs.

2.1 LIFE ON BOARD SHUTTLE TANKERS

This thesis looks at leadership at oil tankers, with a specific focus on shuttle tankers. An oil tanker is a ship constructed or adapted primarily to carry oil in bulk in the cargo spaces. A shuttle tanker is designed to offload oil from an offshore oil field and transport and discharge the cargo to either an oil terminal or another tanker for further transport. The average size of this kind of ship is 250 long meters and 50 meters wide. The number of people on board varies, with a minimum safe manning in accordance with international and national regulations⁵ but usually between 20 and 30 persons. Picture 2 shows a shuttle tanker crew, usually composed of people from several countries. Filipinos are often one of the largest national groups, but the geographic location of the vessel and crewing requirements set by the nations where the ship operates may influence nationalities found on board. For example, in Canadian waters, one would find mostly Canadians, in Brazil, there are several Brazilians on board, and on the Norwegian Continental Shelf, there is usually a mix of Norwegians, Polish people, and Filipinos. Only 2% of the world's 1.2 million seafarers are women (IMO 2019); thus, tanker crews are often all male. Their age may span from late teens to mid-sixties. English is the common work language.

2.1.1 Crew and officers

The work on board is hierarchically organised according to professional affiliation and divided into three main departments: deck, engine room, and catering. There are always four senior officers on a tanker. The captain, as the highest-ranking officer and a navigator by profession, has the command and is responsible for the safe and efficient operation of the ship. The chief

⁵ IMO Resolution A.1047 (27) sets the principles for minimum safe manning for the 174 member states. These are reflected in flag state requirements; for example, Norwegian registered ships must adhere to the regulations of 18 June 2009, No. 666, of the manning of Norwegian ships (Manning Regulations 09). The Maritime Labour Convention published by the International Labour Organization (ILO) will also influence the number of persons on board with respect to seafarers' rights ratified by 82 member states.

mate is the officer next in rank, is also a navigator, and runs the deck department. The chief engineer is responsible for the mechanical propulsion as well as the operation and maintenance of the mechanical and electrical installations of the ship. The first engineer is the officer next in rank, running the engine room department of the ship. Figure 1 gives an overview of the different departments and the belonging roles.

The junior officers include the electricians(s) and cadet(s). At a shuttle tanker, there is a minimum of one electrician, but cadets are not always present as they are apprentices staying on board for a limited time until they meet the requirements to be certified as junior officers, eventually becoming senior officers as they gain competence and meet sea time requirements of higher-ranking roles. Sometimes two engineers or mates with the same rank are found on board. They may substitute someone with a lower rank; the opposite is not possible though because of safe manning and certificate requirements.⁶



Picture 2 Crew at shuttle tanker operating in Brazilian waters.

⁶ The International Convention on STCW for Seafarers, published by the IMO (2011), sets general standards for medical fitness and the qualification of seafarers as well as duties on board. There are special training requirements for oil tanker crew members (IMO 2011: 43).

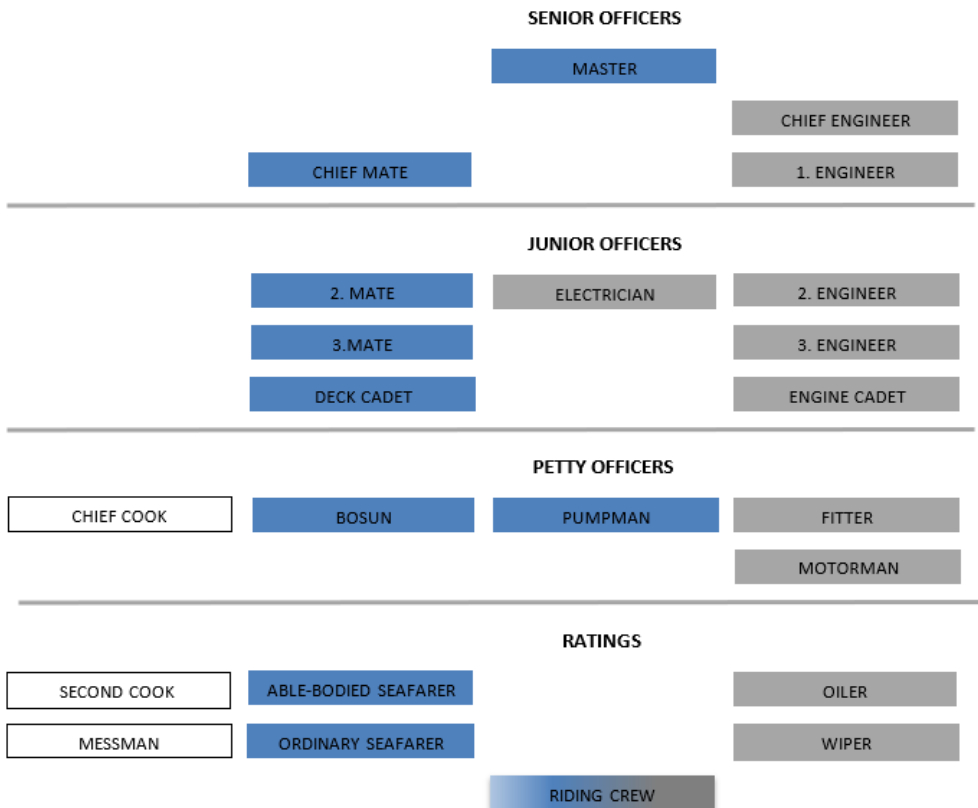


Figure 1 Organisational hierarchy and roles at a tanker.

The cook oversees the catering department and supervises the daily work of the second cook and the messman. The job includes food planning and preparation and the ordering of supplies. The bosun supervises the daily work performed by the deck ratings on behalf of the chief mate, for example the general cleaning and maintenance of the ship not performed by the engine department. The bosun and the deck ratings also carry out tasks related to anchoring and mooring as well as the loading and discharging of oil. The pumpman is responsible for handling and maintaining all oil-handling equipment on the ship, including pumps (thus the title). The motorman supports the fitters, who are usually semi-skilled and mechanically trained. The number of ratings may vary; usually, there are at least four persons with the rank of able-bodied seafarer or ordinary seafarer. The riding crew are supernumerary persons on short contracts, usually hired on a need basis to perform specific unskilled

maintenance jobs either with the engine or the deck department, for example picking rust or painting.

The number of months an individual is aboard in one stretch varies with rank, nationality, and fleet affiliation. Senior European officers in the North Sea have a system: four weeks at work and four weeks off. Some of the lower-ranking crew may stay on board for up to ten months. Senior officers are commonly employed by the shipping company and usually work on the same boat for several years. Junior and petty officers muster on the same boat as the previous trip as far as possible in accordance with the crewing need of the company. This also applies to the crew in general, but some only have short-term contracts with the shipping company, and which vessel they join will vary.

The work hours while on board are regulated by the Maritime Labour Convention, published by the International Labour Organization (ILO). Twelve-hour daytime shifts are common for ratings and petty officers as well as the master and chief engineer while in open sea. This change, for example, during tanking, mooring, or harbour operations, which may require night work and longer work hours. The other officers usually work six- or eight-hours shifts to maintain safe manning of the ship 24/7.

2.1.2 Offloading operations and DP technology

A shuttle tanker is designed to transport oil from an offshore oilfield as an alternative to pipelines. After the ship is loaded, the oil is transported and discharged either to an onshore refinery or to another tanker for further transport. These are core activities, and all tasks on board are structured and organised around these tasks. For example, the engine department is required to follow specified procedures and increase the manning while offloading, the electrician must verify and test certain parameters of the DP software system during operations, and the deck ratings, led by the bosun, will manually connect and disconnect the hose between the ship and the offloading unit. All the work is led from the bridge according to oilfield specific procedures, oil company requirements, and national and international legislations.

Offloading operations require a high degree of accuracy as the ship needs to be connected to the offloading unit. To perform the job, a semi-autonomous computerised system called the DP is used to control the position of the ship. The DP is operated from the bridge, and the deck

officers operating the system must be certified as DPOs in accordance with industry requirements (International Marine Contractors Association 2016; IMO 2011: 43). Once the DP is activated, the operator’s main tasks are to monitor the system and the environment, enter commands (e.g. change heading or position), take precautionary actions if something is amiss and be prepared to intervene, and take manual control of the vessel if the system does not function in accordance with a set of specified criteria.

An average shuttle tanker is 250 meters long, which means little room for error when staying at approximately 300 meters from an offloading unit. Risk during operations relates to weather and wind current changes, DP system failures (e.g. loss of navigation aids or sensors), or power supply failure. Should critical system faults occur, the DP can be disengaged, and the vessel controlled manually by the deck officers. The worst-case scenario is a total loss of engine power, where the ship drifts uncontrollably and collides with the installation. Such a scenario involves a substantial risk for personnel injuries in addition to material and environmental damages and potential production downtime.



Photo: Kristian Topp. Copyright Kongsberg Group

Picture 3 DP work station at shuttle tanker bridge.

2.1.3 Ship management

The description above indicates that ship management is influenced by several factors. The senior officers of tankers are responsible for ensuring that work on board is carried out in accordance with international and national regulations, which set clear limits for the actions of the maritime leaders. Much of the shipping industry is regulated by the IMO,⁷ a United Nations specialised agency responsible for the safety and security of shipping. Its main role is to create an effective and fair regulatory framework for the industry that is universally adopted and implemented. Table 2 gives an overview of the main safety codes adopted by the IMO and the 174 member states. SOLAS is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The first version was adopted in 1914 in response to the *Titanic* disaster. SOLAS includes special requirements for tankers. Fire safety provisions, for example, are much more stringent for tankers than ordinary dry cargo ships.

Table 2 Safety-related regulations adopted by IMO

SAFETY-RELATED IMO CODES

- International Convention for the Safety of Life at Sea (SOLAS), 1914
- International Convention on Load Lines (LL), 1966
- Convention on Facilitation of International Maritime Traffic (FAL), 1967
- International Regulations for Preventing Collisions at Sea (COLREG), 1972
- International Convention for the Prevention of Pollution from Ships (MARPOL), 1973
- International Convention on Maritime Search and Rescue (SAR), 1979
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978
- Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SUA), 1988

A central part of the SOLAS convention is the ISM Code, which provides the standard for the safe management and operation of ships and pollution prevention (ISM Code 2018). A shipping company must establish procedures, plans, and instructions for key shipboard operations to ensure safety, the prevention of human injury or loss of life, and the avoidance of damage to the environment. The officers at a ship shall implement the requirements given by the shipping company and ensure that the work is carried out in accordance with the safety

⁷ <http://www.imo.org/en/About/Pages/Default.aspx>

management system. The ISM Code defines the following responsibilities and authority of a ship master (2018):

1. implementing the safety and environmental protection policy of the company;
2. motivating the crew in the observation of that policy;
3. issuing appropriate orders and instructions in a clear and simple manner;
4. verifying that specified requirements are observed; and
5. periodically reviewing the safety management system and reporting its deficiencies to the shore-based management.

To supervise performance and promote compliance with the rules and procedures described above are thus important aspects of maritime leadership. In addition, the deck and the engine room officers must have in-depth technical knowledge of the vessels and the systems they operate to perform the job safely and efficiently.

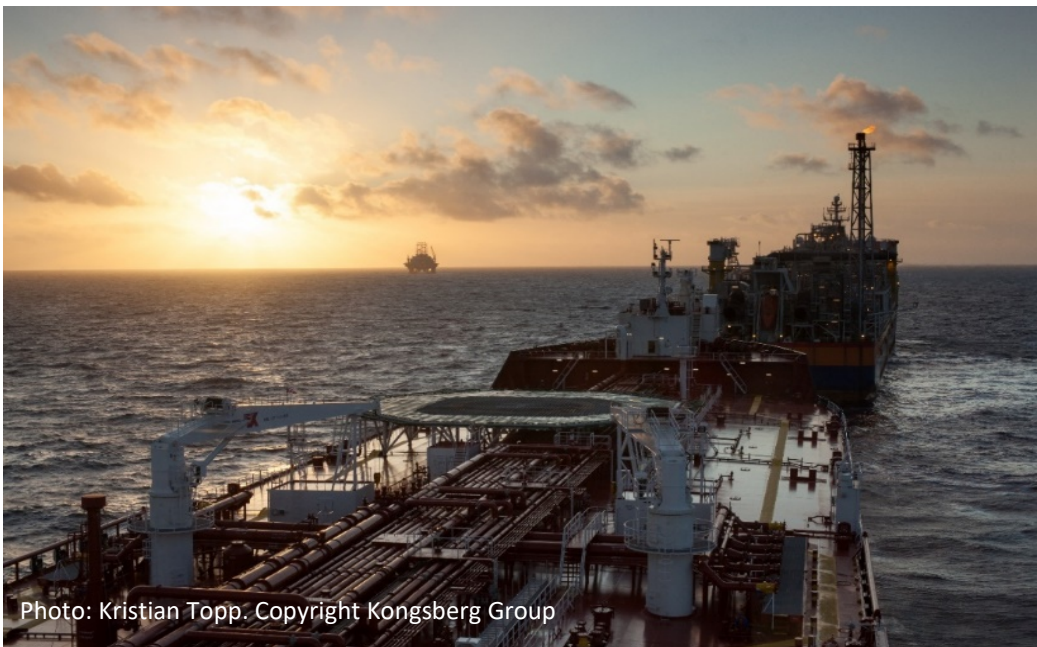


Photo: Kristian Topp. Copyright Kongsberg Group

Picture 4 Proximity to offloading unit when connected.

2.2 CERTIFICATION AND SIMULATOR-BASED TRAINING OF DECK OFFICERS

Deck officers at tankers must meet several requirements to be certified or renew certificates. The International Convention on STCW, published by the IMO (2011), regulates training standards for officers at merchant vessels. The minimum standards of competence are given in detail. Most relate to technical requirements and to navigational and technical knowledge. The latest version of the STCW also enforces leadership and teamwork training and highlights several leadership and managerial skills (IMO 2011: 122, Table A-II/2). The STCW builds on competency-based training principles and emphasises outcome-based education and evaluation practices. This means that seafarers need to demonstrate learning outcomes not only by using written or oral tests but also by demonstrating their level of competence in authentic assessments based on performance-based tasks applied in the real world or a contextually similar environment. The latest version of the convention highlights the use of simulators for the training, certification, and recertification of seafarers.



Figure 2 Layout and design of an advanced bridge simulator.

A bridge simulator can be described as an advanced computer where the equipment usually found at a real ship bridge is placed into a virtual world. With the aid of software technology and digital projections, real-world artefacts or events are replicated to provide realistic training in a risk-free environment. The layout and instrumentation of the bridge, the forces acting on the ship, and virtual images of the ship's surroundings (e.g. other vessels, harbours, or weather conditions) are combined to provide the feeling of a genuine work environment. Figure 2 illustrates the design and layout of an advanced bridge simulator. Much of the training of deck officers is performed in such full-mission ship bridge simulators as this one. Professional deck officers at shuttle tankers are required to undertake specific training to operate the DP system in accordance with the guidelines for the training and experience of key DP personnel, published by the International Marine Contractors Association (IMCA). Some of the training may be done on board, but training provided by maritime simulator centres is a central part of both the basic training to be certified as a DPO and retraining to maintain certificates.⁸ Picture 5 is from a bridge simulator used to train DPOs.



Picture 5 DP training in bridge simulator.

⁸ Two main training schemes are accepted to meet the competence requirements stated by the IMCA (2016). The Nautical Institute (DPSTTC-V1-01/02/2018) puts larger emphasis on in-service experience in the revalidation of certificates than the DNVGL scheme (DNVGL-RP-0007:2014-04), which highlights simulator assessments to demonstrate needed competence.

Maritime simulator-based training programs for professional officers generally contain both classroom lectures and tasks in a simulator. Figure 3 gives an overview of the main elements. The lectures are usually intended to offer theoretical knowledge and an in-depth understanding of what is practiced during the simulator exercises. The training typically starts with a briefing, followed by a simulator session, and ends with a debriefing.

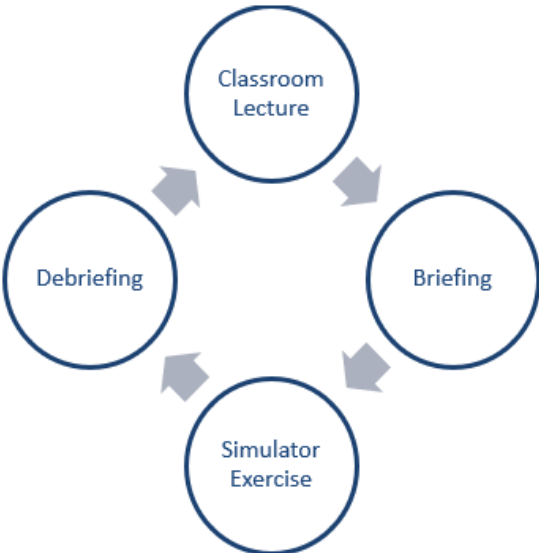


Figure 3 Main elements in simulator-based training.

The briefing is used to explain to the participants what is expected of them during the simulator session. The purpose of the simulation and the learning objectives are clarified, and practical information about the simulator scenario is given. The simulator exercise usually commences immediately after the briefing. The simulator sessions are designed to meet the training objectives and typically contain various problems to be solved by the course participants. The length of an exercise varies from less than an hour to several hours, depending on the scope of the training. The debriefing is carried out after the simulation and revisits critical events from the exercise to ensure learning.

3 THEORETICAL FRAMEWORK

This study aims to contribute to the understanding of safety leadership and explore how bridge simulators can be used to train deck officers. The term *safety leadership* refers to 'leadership behaviours in relation to safety outcomes' (Flin et al. 2008: 131). This points to two theoretical fields: safety and leadership. Thus, the theoretical framework starts by describing safety as a concept, pointing to three different understandings that are applicable to the maritime domain. This is followed by a review of leadership perspectives relevant to the ship officer role, which includes the transformational leadership model (Bass and Riggio 2006; Bass and Avolio 1994), different skills and perspectives, and leadership as a social construction process. The next section presents theories pertinent to the simulator-based training of deck officers, describing the term *simulator fidelity*, reviewing different aspects of the training of professionals, and considering CRM as a leadership training program. The last section summarises the theoretical framework, defines *safety leadership*, and suggests how knowledge about social processes may be valuable to gain new insight into the simulator-based training of professionals.

3.1 SAFETY

Although much research has been devoted to studies on safety, the concept is not well defined in the safety literature and can be understood differently (Antonsen et al. 2017; Møller et al. 2006). Safety can be described as the absence of risk, as the presence of organisational factors leading to safe operations, and as an ability to adapt to changes. These three approaches are presented in separate sections below.

3.1.1 Safety as the absence of risk

Møller et al. (2006) provide a conceptual analysis of the standard definition of safety applied in technical perspectives. In this context, safety is usually defined as the antonym of risk; if risk is low, then safety is high. Here, it is common to assume that the severity of harm and probability are the major components of risk (e.g. Aven and Renn 2009; Aven 2009; Møller et al. 2006). There are two prevailing definitions of risk: '(1) risk is a situation or event where something of human value (including humans themselves) is at stake and where the outcome is uncertain; (2) risk is an uncertain consequence of an event or an activity with respect to something that humans value' (Aven and Renn 2009: 1). Møller et al. (2006) conclude that

safety is more than these two aspects and therefore cannot be regarded as an antonym of risk. They include uncertainty as a third dimension in their understanding of safety, making a distinction between absolute and relative safety and objective and subjective safety. They claim that objective safety is not attainable and argue that an intersubjective concept of safety should be the focus in technical and scientific applications of safety: 'The closest we can get to objectivity is a safety concept that is intersubjective in two important respects: (1) it is based on the comparative judgments of severity of harm that the majority of humans would agree on, and (2) it makes use of the best available expert judgments on the probabilities and uncertainties involved' (Møller et al. 2006: 427). They suggest using the comparative term '[at] least as safe as' (ibid.), offering a comprehensive description of the term that includes three factors: the severity of harm, the probability that harm will occur, and the uncertainty of our knowledge about the harm.

Aven (2009) challenges their analysis and reasons that if risk is understood as the uncertainty about and the severity of the consequences of an activity, safety may, in some instances, be compared to *acceptable risk*. This approach includes a judgement of the socially acceptable level of risk in any given instance and that probability assessments are based on the certain background knowledge of an expert or a lay person. Shuttle tankers' operations are risk prone. Safety measures on board tankers are intended to reduce this risk, for example with the use of risk analyses and DP equipment. The discussion above indicates that safety in this context cannot be understood with respect to the dimension of harm and probability alone but needs to be understood in relation to situational and organisational factors as well as the experience and knowledge level of the officers at these ships.

3.1.2 Safety as the presence of desirable organisational factors

Safety is not only about avoiding unwanted harm but also about achieving a desirable organisational practice. This is the core assumption in one of the major fields in safety science, the theory of HROs (e.g. Weick and Sutcliffe 2015; Rosness et al. 2010; Weick et al. 1999; LaPorte and Consolini 1991; Weick 1987). This theory was developed partly as a response to the normal accident theory, where major accidents are regarded as unavoidable in a modern society characterised by complex and tight coupled systems (Perrow 1984). The HRO perspective argues that some industries seem to avoid major accidents, even though they

operate in high-risk contexts and under complex technological and organisational conditions (e.g. military aircraft carriers, hospital emergency rooms, and air traffic control centres) (Weick and Sutcliffe 2015, 2007, 2001; Rosness et al. 2010; LaPorte and Consolini 1991; Weick 1987). Operational aspects and performance at the *sharp end* are considered central in this perspective.

Three core factors leading to safe operations are highlighted in HRO theory:

1) *Organisational redundancy* (LaPorte and Consolini 1991) indicates that an organisation is structured or manned so that errors can be caught through overlapping responsibilities and expertise. In a maritime context, this is exemplified in the roles and tasks of the captain, the chief mate, the chief engineer, and the first engineer.

2) *An ability to adapt spontaneously and flexibly* (ibid.) is needed under demanding circumstances. In potentially dangerous situations, expertise is valued more highly than formal rank, and interaction becomes more informal. Those with experience and technical knowledge are given leeway to allow them to solve the problem and make decisions. In practice, this will often mean that decisions are taken by those closest to the hazards. In a shipping company, the officers are regarded as experts.

3) *Mindfulness* (Weick and Sutcliffe 2015, 2007, 2001) is regarded as a cluster of features that enables close attention to all kinds of deviations from the normal situation, even smaller deviations, and the ability to assess whether these may be due to systemic weaknesses. Here, five factors are described as central if an organisation is to discover and manage unexpected events (ibid.): preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, deference to expertise, and commitment to resilience.

Resilience in an HRO perspective points mainly to an organisation's ability to return to a normal state after disturbances (Woods 2015; Weick and Sutcliffe 2015). Pettersen and Schulman (2016) argue that this is an incomplete definition of the concept. They differentiate among three types of resilience: *precursory resilience*, which concerns a system's ability to monitor and keep operations within a bandwidth of conditions; *restoration resilience*, which concerns the ability to take rapid action to resume operation after temporary disruptions; and *recovery resilience*, which points to a damaged system's ability to recover and be as reliable

and robust as before or even improved. According to the RE perspective, resilience is a form of organisational control: 'The fundamental characteristic of a resilient organization is that it does not lose control of what it does but is able to continue and rebound' (Hollnagel and Woods 2006: 348). The focus of RE is to develop 'principles and practices that are necessary to enable systems to function in a resilient manner' (Hollnagel 2014: 183). Four main abilities are highlighted as constituting a resilient system (Hollnagel 2017; Hollnagel et al. 2011) and may be regarded as core factors leading to safe operations: to *respond* to regular and irregular threats in a robust yet flexible manner; to *monitor* what is going on, including one's own performance; to *anticipate* disruptions as well as the consequences of adverse events; and to *learn* from experienced successes and failures. When these abilities are present, an organisation can better minimise or eliminate unwanted variability, whether it is related to a system's own performance or the environment and can continue normal operations after unexpected events (Hollnagel and Woods 2006).

3.1.3 Safety as adaptability

Hale and Hovden (1998) describe how the understanding of safety has evolved and developed sequentially through three ages of safety: the *technical age*, the *human factors age*, and the *management systems age*. Glendon and Clarke (2016) propose a fourth *integration age* that builds on the other ages and integrates previous ways of thinking into more complex perspectives of safety. Borys et al. (2009) argue that contemporary views of safety need to go beyond merely integrating past perspectives and suggest a fifth *adaptive age* of safety, pointing to the notion of variability and the ability to adapt to changes as important aspects of safe operations in modern organisations. As we saw in the discussion above, variability is a central aspect to the RE perspective, and the ability to pay mindful attention to deviations and to adapt to changes is a key aspect of the HRO perspective.

The RE perspective differs from more design- and rule-based approaches to safety that aim to build safety through planning in advance rather than by increasing the ability to deal with surprises. Hollnagel (2014) uses the terms *Safety I* and *Safety II* to distinguish between these two views on safety. The Safety I perspective is associated with a preoccupation of things that go wrong. Adverse events are analysed in hindsight to understand what went wrong and to define measures to avoid similar outcomes in the future (Hollnagel 2017, 2014, 2013, 2009).

As a supplementary perspective, it is suggested to include knowledge on how and why things go right. This perspective has been labelled *Safety II* (ibid.) and is described as ‘a condition where the number of successful outcomes is as high as possible. It is the ability to succeed under varying conditions. It is achieved by trying to make sure that things go right, rather than preventing them from going wrong’ (Hollnagel 2014: 183).

Safety I and Safety II may be regarded as two fundamentally different ways of viewing and achieving safety, but the two are not mutually exclusive (Hollnagel 2017). A key issue in RE and the Safety II perspective is the importance of performance variability and the ability of individuals to continuously adapt their everyday work to situational changes to ensure that ‘everything goes right’ (Hollnagel 2014: 137). Here, adaptability represents necessary adjustments, is seen as a basis for safety and productivity (Hollnagel, 2014), and builds on a deconstruction of the notion of *human error* (LeCoze 2016). Rather than regarding deck officers as a liability and their actions a threat to safety, they should be seen as an asset that ensures the proper functioning of the modern technological systems on board a shuttle tanker. Things go right because people learn to detect and overcome design flaws and functional glitches and adapt their performance to meet changing demands (Hollnagel 2008). Following this perspective, maritime safety is achieved by officers adapting to the situation at hand and controlling variability rather than constraining it.

3.2 LEADERSHIP

The understanding of what leadership is varies, but most definitions assume that it involves an influence process facilitating the performance of a collective task (Northouse 2016; Yukl 2013; Bass and Bass 2008). This thesis regards leadership as a process of social construction (Yukl 2013; Uhl-Bien 2006) focusing on the complex influence processes that occur among maritime crew, the setting and situations that regulate when and how they occur, the processes involved in the emergence of leadership, and the consequences for safe and efficient work performance. Here, leadership is understood as ‘the process of influencing others to understand and agree about what needs to be done and how to do it and the process of facilitating individual and collective efforts to accomplish shared objectives’ (Yukl 2013: 23).

Knowledge about leadership as a profession beyond military operations emerged early in the last century (Northouse 2016; Yukl 2013; Bass and Bass 2008). Most of the early theories

focused on how to control and systematise work, for example *scientific management* (Northouse 2016). Only a little later was the attention of scientists directed at the leader as a person and did researchers become interested in individual characteristics possessed by great leaders (ibid.). The basic premise in this early work was that people are born with certain traits that make them suitable as leaders and that leadership can be defined as a universal phenomenon (Northouse 2016; Yukl 2013; Bass and Bass 2008). Many different qualities have been discussed and identified in several studies. Northouse (2016) points to five major leadership traits that seem to be common in much of the research: intelligence, self-confidence, determination, integrity, and sociability. This *trait perspective* suggests that some people have inborn qualities that make them fit or unfit as leaders. This thesis takes a contrasting view, suggesting that leadership can be learned (Flin et al. 2008; Northouse 2016).

Various theories, in addition to the trait theory, have been proposed to explain leadership performance. Style theories, contingency (situational) theories, charisma and transformational theories, leader–member exchange (LMX), and relational leadership are some examples (Northouse 2016; Yukl 2013; Bass and Bass 2008; Uhl-Bien 2006). A review of the available literature related to safety indicates two theoretical approaches to leadership that dominate this field: the *transformational leadership model* (Kim and Gausdal 2017; Glendon and Clarke 2016; Nielsen et al. 2016; Pilbeam et al. 2016; Clarke 2012) and the *non-technical skills* approach (O'Connor and Long 2011; Grech et al. 2008; Flin et al. 2008; Salas et al. 2006; Helmreich et al. 1999). The transformational model has been one of the most dominant research perspectives on leadership in the last three decades (Bass and Riggio 2006; Bass and Avolio 1994), also in safety studies (Glendon and Clarke 2016). The model distinguishes between transformational and transactional leadership and may be understood as instrumental in describing the positive and negative aspects of leadership with respect to safety (ibid.). An introduction to the model is given below, along with a review of how this theory may contribute to our understanding of leadership and organisational safety. The non-technical skills approach, proposed by Flin et al. (2003), was originally developed as a complement to the technical training of pilots but has later been developed and used in other industries, including shipping (Flin et al. 2016; Flin et al. 2008; Grech et al. 2008). The second section presents theories related to leadership skills, with a focus on skills identified as

important to safe and efficient performance in high-risk work settings. The first two sections describe the attributes of individuals as they engage in leadership. The last section supplements these dominantly individualistic views with a relational perspective where leadership is described as a process of social construction (Uhl-Bien 2006).

3.2.1 Leadership as transformational and transactional

The transformational leadership model describes three main kinds of leadership (Bass and Bass 2008; Bass and Riggio 2006; Bass and Avolio 1994): transformational, transactional, and passive. *Transformational leadership* is created and described using four different components (Bass and Riggio 2006): *idealised influence*, *inspirational motivation*, *intellectual stimulation*, and *individualised consideration*. *Transactional leadership* is characterised by an emphasis on compliance with rules, procedures, and regulations. Bass and Riggio (2006) describe the positive elements of transactional leadership as *contingent reward* and *management by exception active* and use the term *management by exception passive* to describe a less desirable and passive leadership. An extreme form of passive leadership behaviour is labelled *laissez-faire* and understood as a *non-leadership*. Table 3 gives an overview of the three leadership types and their components in a maritime leadership context in accordance with the categories described in the transformational leadership model.

Laissez-faire leadership is described as dysfunctional and even harmful in relation to safety (Glendon and Clarke 2016). Kelloway et al. (2006) found that passive leadership had significant negative effects on safety, leading to increased incidence of occupational injuries and adverse safety events. They claim that passive leadership may negatively influence the level of safety consciousness and perceptions of the importance of safety. Mullen et al. (2011) drew similar findings in their study of *inconsistent leadership*, where leaders alternated between transformational and passive leadership. Passive leadership where safety issues are avoided reduces the positive effects of transformational leadership. Kelloway et al. (2006) found that this effect is stronger for a sample of young healthcare workers compared to a sample of older workers. Despite these claims, Nielsen et al. (2016) show how current knowledge on leadership and workplace safety is mainly based on cross-functional studies focused on constructive forms of leadership. They suggest that future studies must include the impact of

both destructive and constructive forms of leadership and how leadership is related to safety over time.

Table 3 Examples of transformational, transactional, and passive leadership

TRANSFORMATIONAL LEADERSHIP

An officer enhances the motivation and job performance of crew by employing:

- **Idealized influence:** (S)he is a clear role model for safety and emphasises a collective understanding of goals among the crew. Considers the moral and ethical implications of decisions, and has confidence in, and respects, the crew.
- **Inspirational motivation:** (S)he creates team spirit and inspires the crew by setting high standards and stimulating enthusiasm and optimism on board. Goals are communicated clearly.
- **Intellectual stimulation:** (S)he encourages the crew to assess existing practices and established truths continuously to reduce risk and to make suggestions that can make the job safer and more efficient. Individuals are never criticized in public.
- **Individualized consideration:** (S)he delegates tasks and gives subordinates new challenges so that they can experience personal growth and develop their strengths. Acts as a mentor or coach educating personnel by listening to individual needs, providing support and advice.

TRANSACTIONAL LEADERSHIP

An officer supervises performance and promotes compliance of rules and procedures by employing:

- **Contingent reward:** (S)he states clear objectives expectations to satisfactory job performance. Praise or material rewards is used to encourage safe and efficient work practices on board.
- **Management by exception -active:** (S)he anticipates problems and takes corrective action by actively monitoring follower's behaviour pays close attention to the work and takes proactive actions when weaknesses or deficiencies in work performance is discovered before they escalate into serious incidents.
- **Management by exception -passive:** (S)he spots and corrects followers' mistakes as problem arise wait for discrepancies or errors to occur, or for someone to complain, before he acts.

NON-LEADERSHIP

An officer avoids or refrains from leadership by employing:

- **Laissez faire:** (S)he avoids getting involved in the work or when important issues arise, is unavailable to the crew, lacks opinions on important issues, does not intervene in conflicts, delays actions or does not act and makes decisions reluctantly or not at all.
-

Glendon and Clarke (2016) claim that most current conceptualisations of safety leadership draw on the theoretical framework of the transformational leadership model. One example is the SAFER model (Wong et al. 2015), which emphasises five key leadership behaviours: speaking about safety, acting safely, focusing on safety, engaging others in safety initiatives, and recognising safe performance at work. Glendon and Clarke (2016) argue that transformational and transactional leadership are to be regarded as complementary and

where favourable practice depends on the situation. In work situations characterised by a high degree of routinisation, they suggest that transactional leadership would be most appropriate, whereas when routinisation is low, transformational leadership is most suitable. Their review also indicates that transformational leadership is primarily associated with safety participation, while transactional leadership is primarily associated with safety compliance.

Yukl (2013: 286) criticises the transformational model for having 'ambiguous constructs, [an] insufficient description of explanatory processes, a narrow focus on dyadic processes, omissions of some relevant behaviours, insufficient specification of situational variables, and a bias towards heroic conceptions of leadership'. Pilbeam et al. (2016) support much of this critique in their literature review of studies on organisational safety compliance and leadership. They point particularly to a lack of contextual factors in the current research and the need for a better explanation of situational variables. Most of the existing theories in this perspective are leader centred, focusing on how leaders influence followers (Yukl 2013). Reciprocal influence processes, such as shared leadership and mutual influence among the followers themselves, need more attention (Nielsen et al. 2016; Yukl 2013). The transformational model is also criticised for treating leadership as a personal disposition or trait rather than a behaviour that people can learn (Northouse 2016). Northouse (2016) claims that it is difficult to exactly define the parameters of the model and that the different components describing transformational leadership (see Table 3) overlap to a large degree, making it problematic to measure them. Following this argument, it may be difficult to change how officers act as leaders relying merely on the transformational leadership model. In a training setting, it may be useful to look at more specific leadership skills that define safe and efficient task performance in a sharp end context.

3.2.2 Leadership skills in high-risk work settings

The skills approach to leadership takes a leader-centred perspective as in the trait approach, but focus is shifted from personal characteristics to an emphasis on abilities that can be learned and developed (Northouse 2016; Yukl 2013; Katz 1955). The perspective is primarily descriptive and provides structures for understanding the nature of effective leadership. It is common to distinguish among three broadly defined categories of skills (ibid.):

- *Technical skills* entail knowledge about the methods, processes, procedures, and techniques needed to perform a job and the ability to use tools and equipment relevant to work tasks.
- *Interpersonal skills* entail knowledge about human behaviour and interpersonal processes and the ability to work with people.
- *Conceptual skills* deal with logical and analytical thinking and the ability to work with ideas and concepts such as abstractions and hypothetical notions. This includes the ability to anticipate changes and recognise opportunities and potential problems in a work situation.

The relative importance of the various skills depends on the leadership situation, for example a level of management where the top manager may need a higher level of conceptual skills and can do with a lower level of technical skills than a supervisor (Yukl 2013). Because of the importance of the leadership context, the skill model may be weak in general application, particularly since the original work was constructed with data from military personnel only (Northouse 2016).

Leaders – and the interaction between leaders and team members – are critical to safe and effective team performance in HROs (Flin et al. 2008). Saurin et al. (2014) point to the importance of the *resilience skills* of individuals or teams to maintain safe and efficient operations during expected and unexpected situations. Flin et al. (2008) identify four elements associated with leadership skills in this context: using authority and assertiveness; providing and maintaining standards; planning and prioritising; and managing workload and resources. They underline that these not only apply to the leaders but sometimes also apply to the team members. Flin et al. (2003) developed a specific *non-technical skills framework* to train and assess pilots. This has later been adjusted and applied in many other industries, including shipping (Flin et al. 2016; Flin et al. 2008; Grech et al. 2008). Non-technical skills are defined as ‘the cognitive, social, and personal resource skills that complement technical skills and contribute to safe and efficient task performance’ (Flin et al. 2008: 1). Flin et al. (2008) claim that these skills are important for safe and efficient performance in high-risk work settings.

The framework consists of four primary categories (Flin et al. 2003: 100; see Table 4 for an overview). The first two are regarded as social skills and the last two as cognitive skills. The

social skills overlap to a certain degree since both refer to group processes. *Cooperation* is concerned with mutual assistance and the team atmosphere during work, while *leadership and managerial* skills cover all aspects of initiative, coordination, and goal setting. *Situation awareness* points to a person’s ability to have a situational overview and to fit this knowledge into a mental model to trigger problem recognition. *Decision making* is the process of reaching a judgement or choosing an option. This framework points to a set of skills that are also relevant to officers at shuttle tankers and currently applied in CRM training for seafarers, discussed in more detail in Section 3.4.3.

Table 4 Overview of non-technical CRM skills for pilots.

	CATEGORY	ELEMENTS
Social skills	Cooperation	<ul style="list-style-type: none"> - Team building and maintaining - Considering others - Supporting others - Conflict solving
	Leadership/ Management	<ul style="list-style-type: none"> - Use of authority/assertiveness - Providing and maintaining standards - Planning and coordination - Workload management
Cognitive skills	Situation Awareness	<ul style="list-style-type: none"> - Awareness of aircraft systems - Awareness of external environment - Awareness of time
	Decision-Making	<ul style="list-style-type: none"> - Problem definition and diagnosis - Option generation - Risk assessment and option selection - Outcome review

The perspective claims not to be a trait model, but it is easy to argue the opposite because of its emphasis on individual attributes such as motivation, cognitive abilities, and personal characteristics. Still, Northouse (2016) claims that the skills approach contributes positively to our understanding about leadership. The focus on competencies that a person can learn, develop, and improve makes it easy to understand and accessible to many. The wide variety of components and subcomponents provides a structure that can be consistent with the curricula of education programs for maritime officers and relates to subjects such as problem solving, conflict management, listening, and teamwork. Northouse (ibid.) emphasises that this broad scope may also pose a problem and that the subject matter is no longer leadership but

includes a variety of topics such as motivational theory, personality theory, or perspectives on critical thinking.

3.2.3 Leadership as social construction processes

According to Dachler and Hosking (1995), relational aspects are often left untheorised in the leadership field. They claim that ‘what usually gets ignored are the social processes by which leadership is constructed and constantly in the making’ (ibid.: 15). Aubert and Arner (1959) demonstrated the importance of social structures within the community of a ship in their classic work; thus, this subchapter supplements the individualistic perspectives above with a description of maritime leadership as a process of social construction (Uhl-Bien 2006; Hosking 2006; Dachler and Hosking 1995). Following this view, leadership takes place in relational dynamics in an organisation. Uhl-Bien (2006) describe this as *relational leadership*, defining it as ‘a social influence process through which emergent coordination and change are constructed and produced’. This implies that to understand maritime leadership, understanding what leaders do and their individual entities is not enough; we also need to focus on social processes and combinations of interaction relations and contexts. In this thesis, it is particularly important to understand how safety may be socially constructed and distributed among officers.

Gherardi (2017) notes that safety knowledge is deeply rooted in individual and collective identity and is primarily knowledge that is tacit and taken for granted. She stated that ‘safety is emergent from the working practices of a community; it is a collective knowledgeable doing and is embedded in the practices that perform it’ (ibid.: 12). Hence, maritime officers’ safety knowledge needs to be considered as a social and collective accomplishment rooted in a context of interaction, situated in a system of ongoing practices and learned through participation in a maritime community, not only in a formal setting such as simulator-based training but also while on board.

Hung and Cheng (2002) argue that this enculturation within a community is *learning to be* and different from *learning about*, which can be described as acquiring technical knowledge or theoretical understanding of leadership. Brown and Duguid (2000) highlight that learning within a community also relates to the development of a person’s identity since the members assimilate certain depositions, attitudes, and beliefs as a part of belonging to the community.

This learning process is described by Wenger (2000: 227) as ‘an interplay between social competence and personal experience. It is a dynamic two-way relationship between people and the social learning systems in which they participate. It combines personal transformation with the evolution of social structures.’

Lave and Wenger (1991) highlight a social and cultural view on learning in their theory of *community of practice*. Here, learning is regarded as a social process, influenced by the setting in which it takes place and structured by the tools available in specific situations (Wenger 1998). According to Wenger (2011: 1), communities of practice are ‘groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly’. These groups can be regarded as vehicles of professional and situated learning, distinguished by a shared domain of interest and a shared competence (Lave and Wenger 1991). Lave and Wenger (1991) emphasise that members in a community of practice build relationships and learn by interacting with one another and by engaging in joint activities and information sharing. They describe how newcomers in a community are taken from *legitimate peripheral participation* to full participation as a part of this process. The members eventually develop a shared practice and repertoire of resources involving tools and common ways of addressing problems, experiences, stories, and others (Lave and Wenger 1991: 1–2). Following this perspective, leadership practice is developed and learned as ‘an interplay between social competence and personal experience. It is a dynamic two-way relationship between people and the social learning systems in which they participate. It combines personal transformation with the evolution of social structures’ (Wenger 2000: 227). This indicates that leadership can be understood as a social and situated negotiation process that occurs between the maritime community and the individual officer – a social process because it takes place in a group or a team, where the team and the individual continuously influence each other, and a situated process because it is context bound and cannot be separated from the situation in which it takes place.

3.3 SIMULATOR-BASED TRAINING AND LEARNING PROCESSES

Theories and studies that shed light on the simulator-based training of professional maritime officers are presented here. The chapter starts by reviewing literature that discuss simulator technology and introduces the term *simulator fidelity*. This is followed by a general discussion

on the training of professionals before looking into the more specific CRM programs that are developed to train sharp end operators in non-technical skills.

3.3.1 Simulator fidelity

The training of seafarers has changed radically over the last twenty years. Seafaring skills have traditionally been developed under the supervision of senior officers in an apprenticeship regime on board vessels (Gekara et al. 2011). Since the 1950s, onshore simulators have been used to train and certify mariners (Sellberg 2017). Today much of the training is performed by maritime education and training providers and takes place in bridge or engine room simulators (Sellberg 2017; Ghosh et al. 2014; Gekara et al. 2011; Sampson et al. 2011; Emad and Roth 2008). Bridge simulators were initially used to train technical skills related to the safe navigation of a vessel, for example navigation, passage planning, and basic ship handling (Hanzu-Pazara et al. 2008). Today simulators are used in the maritime industry to offer a wide range of operation-specific training of mariners, for example towing and anchor handling, offshore operations, ship-to-ship lightering, and port operations.

The term *simulator fidelity* is often used to indicate the degree of physical resemblance between a computer-created simulated environment and a real work environment (Hontvedt and Arnseth 2013; Dahlstrom et al. 2009; Liu et al. 2009; Alessi and Trollip 2001; Salas et al. 1998). It is characterised as high or low depending on how immersive or complex the simulations are perceived (Hontvedt and Arnseth 2013; Liu et al. 2009). The degree of fidelity increases as the simulated environment becomes more like the physical work environment, such as mimicking the physical layout of a ship bridge or the physical forces affecting a vessel (Hontvedt and Arnseth 2013; Liu et al. 2009). According to Liu et al. (2009), the concept of fidelity is defined in many ways, but most definitions emphasise the physical characteristics of the technology. Allen et al. (1986) distinguish between physical and functional factors, the degree to which a training simulator *looks* and *acts* like actual equipment. According to Liu et al. (2009), it is common to include several elements in *physical fidelity*, such as replications of motion cues (motion fidelity), actual hardware and software (equipment fidelity), and visual-audio stimulus (visual-audio fidelity). The duplication of visual stimuli through projected images of vessel environment is also described as photorealism (Dahlstrom et al. 2009). Liu et

al. (2009) indicate that *functional fidelity* can be understood as the psychological-cognitive replication of actual devices and stimuli in the work environment rather than physical entities.

There is an ongoing debate in the field of simulator training that concerns the level of fidelity and the extent to which the technical characteristics of a training device need to duplicate an actual work environment to ensure effective learning (Hontvedt 2015; Hamstra et al. 2014; Hontvedt and Arnseth 2013; Rystedt and Sjöblom 2012; Dahlstrom et al. 2009; Liu et al. 2009; Salas et al. 1998). Salas et al. (1998) discovered a tendency in aviation to emphasise simulator design over human-centred training systems based on a belief that increased simulation realism automatically leads to improved learning. According to Dahlstrom et al. (2009), a direct causal relationship between simulator fidelity and the quality and transferability of the training to an actual work environment is often taken for granted and assumes that 'if it looks real, it will provide good training' (ibid.: 308). Rystedt and Sjöblom (2012) claim that authentic simulations also depend on the authenticity of the collaborative activities among the participants. They demonstrate that appropriate guidance and feedback to trainees along with situated and social aspects are vital features in practitioner training. Full-mission bridge simulators intend to mirror the situated context for team cooperation and problem solving as close to the real world as possible. Hontvedt and Arnseth (2013) claim that the ability to enact the social interactions that characterise the work situation is a prerequisite for successful mariner training.

3.3.2 Training professionals

The goal of simulator training is to allow the trainees to explain, analyse, and synthesise information and emotional states to improve performance in similar situations in the future (Rudolph et al. 2007). Fanning and Gaba (2007) claim that simulator training is a learning process where knowledge is created through the transformation of experience and therefore fits the description of *experiential learning* given by Kolb (1984). They describe how this kind of training offers an opportunity to go through the experiential cycle in a structured manner. The tasks in the simulator offer the trainees a concrete experience, which is then reflected upon and discussed with peers. Based on lessons learned, the trainees may modify work practice, test this in the next run in the simulator, or apply what is learned in real life and develop their professional practice. Fanning and Gaba (2007) claim that experiential learning

is particularly suited for the learning of professionals where the integration of practice and theory is pertinent and non-stop.

Helping trainees develop and integrate insights from direct experience into later action through rigorous reflection on practice is crucial in this learning process (Rudolph et al. 2007). Salas et al. (2008) demonstrate how reflecting on recent performance is critical for medical teams to gain insights and use that knowledge later and highlight post-simulation debriefing as a tool for experiential learning. Schön (1995) coined the term *reflective practice*, demonstrating that experience alone does not necessarily lead to learning; deliberate reflection on what drives one's own professional practice is essential. Rudolph et al. (2007) indicate that the collaborative setting of simulator-based training is well suited for reflective practice. Here, learning occurs when the trainer and the trainees jointly explore the frames of action that led to the actual performance in the simulator and together develop new frames for action. Following Schön (1995), professional practitioners get their experience from repetitive action and then build up their *knowing-in-action* through a subsequent development of a repertoire of expectations, images, and techniques. Over time, the practitioners' knowledge tends to become increasingly tacit, individual, intuitive, and automatic and develops as a *reflection-in-action* that will benefit the situation at the time of an event. To change work practice requires *reflection-on-action*, where the practitioner revisits an event, thinks back on what happened, and adjusts future actions based on this knowledge. Rudolph et al. (2007) regard simulator training as helpful in this process.

Post-simulation debriefing is regarded as a critical component in simulator-based training as it helps trainees develop and integrate insights from training tasks into future work practice through structured and facilitated sessions (Sellberg 2018; Sellberg et al. 2018; Crichton 2017; Sawyer et al. 2016; Rudolph et al. 2008; Rudolph et al. 2007; Fanning and Gaba 2007). Debriefing is commonly used in the simulator-based training of commercial pilots (Roth 2015; Dismukes et al. 2000), healthcare personnel (Sawyer et al. 2016; Rudolph et al. 2008; Salas et al. 2008; Fanning and Gaba 2007; Rudolph et al. 2007), and mariners (Sellberg 2018; Sellberg et al. 2018; Sellberg 2017; Gosh et al. 2016; Gosh et al. 2014; Sampson et al. 2011; Emad and Roth 2008). The debriefing provides learning by revisiting critical events in the simulator scenario (Sellberg et al. 2018) and usually follows a conversational structure consisting of

different phases (Sawyer et al. 2016; Rudolph et al. 2008; Fanning and Gaba 2007; Rudolph et al. 2007). It can be characterised as a continuous and ongoing assessment between the learning objectives and the trainees' activities (Sellberg et al. 2018). The core of debriefing is to explore social or interpersonal frames of action that influence the team's and individuals' performance during the simulator tasks (Rudolph et al. 2008) and to bridge trainees' experiences from actual work and what is learned during simulator scenarios (Fanning and Gaba 2007).

Roth (2015) describes debriefing as an interactive process, adjusted to the events in the simulator, which will unfold differently every single time because of the trainees' skills and decisions. This implies that the learning process depends on the actors' knowledge and learning trajectories and their interactions with one another in a social setting. In the training of bridge teams, the course participants' experience at sea, prior operational or technology-specific knowledge, experience with similar training settings, and ability or willingness to collaborate with others attending the training can affect the learning outcome. This indicates that experiential learning and reflective practice are central perspectives when examining the simulator-based training of professional officers.

3.3.3 Crew resource management

Simulator training in the maritime domain has primarily been used to learn technical skills. After several serious accidents in the 1990s where human factors were identified as the main cause, leadership and teamwork training was initiated in the industry based on the CRM training programs developed for aviation in the 1980s (Grech et al. 2008). The early training programs started out as classroom-based lectures but have later evolved into simulator-based training. Since 2017, all ship officers have been required to undergo leadership and teamwork training (IMO 2011). The content of the training is guided by the requirements in the latest STCW revision (ibid.), and the training programs are often referred to as BRM (bridge resource management), ERM (engine room resource management), or HELM (human element leadership and management).

CRM was developed as a response to serious accidents where human errors were identified as the main cause and is currently regarded as error management (Helmreich et al. 1999). The training sets out to provide three barriers to the occurrence of errors: to avoid errors from

occurring in the first place; to trap errors and stop them from evolving and having an operational effect; and to mitigate the consequence of errors not avoided or trapped (ibid.). A non-technical skills taxonomy, as described in Section 3.2.2, is often used to pinpoint specific training needs, to structure the CRM training, and to assess individuals (Flin et al. 2016; Flin et al. 2008; Flin et al. 2003).

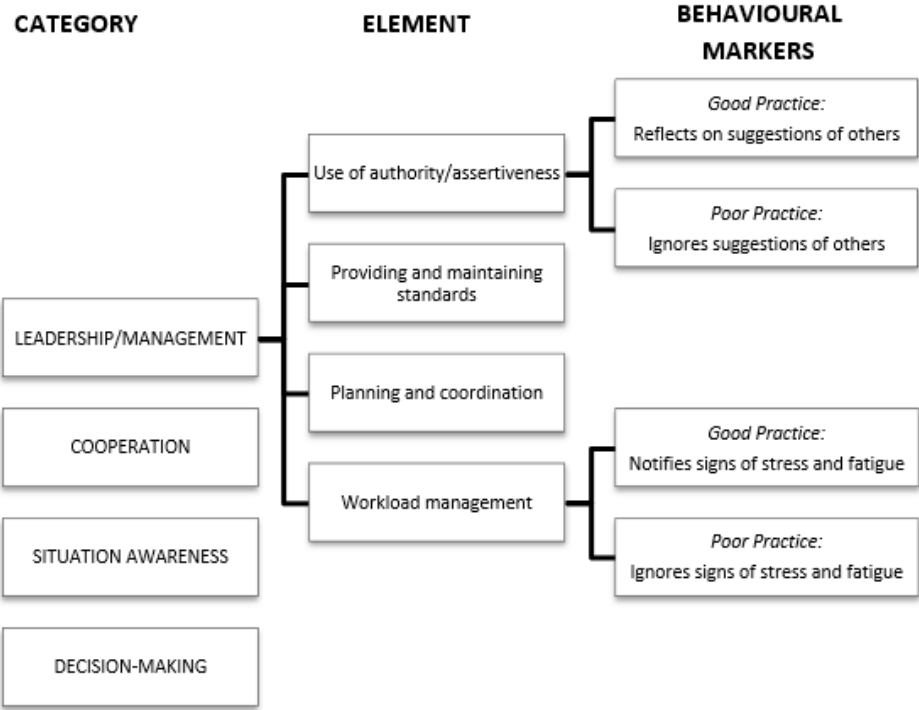


Figure 4 Non-technical skills taxonomy used to observe and assess pilots.

Flin et al. (2008) recommend that a unique taxonomy be developed for any given profession and work setting. The skills selected should be considered as particularly important to safe and efficient work performance in the defined operation and should be given specific attention during training. The elements in such a tool must be directly observable in a training context (ibid.). Individual factors such as health and the ability to cope with stress and fatigue are usually regarded as behaviour-shaping factors that are difficult to observe and measure objectively and are therefore not included (Flin et al. 2003; Flin et al. 2016). The taxonomy is typically a three-level hierarchy, with the skill categories at the highest level, each defined and

divided into several distinct elements. These elements can be further split into several behavioural markers that exemplify both good and poor work practices which may be observed and assessed during simulator sessions by the trainer (Flin et al. 2003; Crichton 2017). Figure 7 depicts a common structure of a non-technical skills taxonomy and gives examples of behavioural markers related to the leadership/management category (Flin et al. 2003).

Grech et al. (2008) claim that CRM training programs have raised awareness about human capabilities and limitations in the maritime domain but that the early programs tended to focus on the sharp end practitioners only and on specific issues such as fatigue, situation awareness, and communication. They indicate that the work of James Reason was instrumental in changing the focus to a more holistic view on safety, widening the scope to organisational factors and technology design. The concept of safety culture exposed how attitudes in the entire organisation may influence safety behaviour at the sharp end, and managers and onshore staff were invited to join the training along with ship crew. Still, Barnett et al. (2005) claim that many of the courses offered today are mostly adopted directly from the aviation model, thus, the need for more tailoring to the maritime industry.

3.4 SAFETY LEADERSHIP TRAINING

This thesis aims to contribute to the understanding of safety leadership and explore how bridge simulators can be used to train deck officers. In the introduction to the theoretical framework, the term *safety leadership* was described as ‘leadership behaviours in relation to safety outcomes’ (Flin et al. 2008: 131). According to Kongsvik et al. (2018), it is imperative that safety leadership ties together the formal and informal aspects of a business and balances the coordination and control of work with an understanding of social processes and psychological dimensions that may influence safe work performance.

In Chapter 2, we saw that the *safety management system* is the primary formal guideline for leadership at a tanker (ISM Code; IMO 2018). This is a fundamental prerequisite and a distinct basis for all daily work performed on board and can be regarded as a formal framework for safety leadership in a maritime context. Hale (2003: 3) defines safety management as ‘the total of activities conducted in a more or less coordinated way by an organization to control the hazards presented by its technology’. Safety management includes the management of

formal and concrete aspects of a business, for example rules, procedures, and checklists that describe how to perform daily work, techniques to reduce errors or uncover risk, methods to report and investigate unsafe acts, or safety campaigns targeting potential risk. It establishes a set of formal constraints and opportunities for maritime officers' action and may form the basis for transactional leadership as it emphasises the leader's role in ensuring compliance with rules and procedures.

Hale (2003) highlights that having a safety management system in place is necessary but insufficient in maintaining safety in high-risk organisations: 'safety management is more than simply a structure rationally fulfilling a control function. For it to work effectively, it requires factors like commitment, involvement, care, trust, alertness, openness to learning, and priority for safety' (ibid.: 3). Reiman and Oedewald (2009) show that safety management systems constitute a frame of action for leaders but that their actions and decisions also depend on the interplay among a set of variables, many of these of an informal quality not easily recognised or controlled by a structured system. Failing to realise the importance of social processes and psychological dimensions and relying merely on organisational structures when practicing leadership may even undermine safety. They point to several pitfalls when it comes to organisational structures and processes in an organisation with segregated and specialised departments as in a shipping company, such as the uncoupling of local practice from standardised procedures, the normalisation of deviance, and the silent deviation of rules. These are the informal features of an organisation as described by Kongsvik et al. (2018). These relate to a leader's understanding of the social and individual factors that may influence the work process. This harmonises with the view of leadership as a process of social construction that takes place during individual and collective efforts to get the job done (Yukl 2013; Uhl-Bien 2006) and calls for transformational leadership where an officer motivates, stimulates, and makes individual considerations.

This thesis regards safety leadership as 'a process that takes care of the formal and informal functions, tasks, roles, and responsibilities that are of importance for maintaining safety in an activity or an organization' (Kongsvik et al. 2018: 25). This view emphasises that leaders need to adjust their leadership to both informal factors and formal requirements to run the ship in an efficient and safe manner. The discussion above implies that leadership can be understood

as a social process and that leadership should be regarded as an outcome of continuously social and situated negotiation processes that take place between the maritime community and the individual officers. This applies to both the leadership process and the skills a leader learns and uses and forms the theoretical backdrop of this study.

The theoretical perspectives presented in this chapter indicate a lack of knowledge about social processes that are relevant to maritime leadership and the training of maritime officers. This thesis sets out to investigate safety leadership by taking a closer look at these processes. The work aims to supplement the prevailing psychological approach to training of deck officers and to bridge the gap between technology design and social processes in simulator-based training programs. This is done by answering four research questions:

1. How is safety leadership understood in a maritime context?
2. What leadership skills do maritime officers need, and how can these be trained?
3. What is the significance of social factors in the simulator-based training of professional deck officers?
4. How is the simulator-based training of deck officers used to manage performance variability and safety at sea?



Photo: Kristian Topp. Copyright Kongsberg Group

Picture 6 View from shuttle tanker bridge.

4 METHODOLOGY

The purpose of this thesis is to contribute to the understanding of maritime safety leadership and explore how bridge simulators can be used to train professional deck officers. This chapter provides a description of the research strategy and design of the study, followed by a presentation of the data collection and the empirical material and an explanation of the analytical approach. The chapter is concluded with a consideration of the scientific quality of the study. The trustworthiness of the research is evaluated with respect to four criteria: credibility, transferability, dependability, and confirmability. Transparency, reflexivity, and research ethics are important facets of social research (Yardley 2000) that relate to the quality of any research. This is partly ensured by the detailed description of the research process given in this chapter, but it also means to take a closer look at the researcher role and how it may influence the work. This is addressed in the first section of this chapter.

4.1 THE RESEARCHER ROLE AND RESEARCH ETHICS

This study is performed within the frames of an industrial PhD, partly funded by the Research Council of Norway (NRC) (grant number 256074). Two industrial partners contribute financially – KM and TK. The first is my employer; the latter is a customer of KM. The data material is collected mainly with these two companies. The three visited tankers were owned and operated by TK, and the interviewed crew members were all employed by the same company. The observed simulator training was at two different centres owned and operated by KM and the interviews with instructors employed by KM and course participants attending training provided by KM. Before I started the PhD project, I was an instructor with KM and has continued this role part time (25%) throughout the project period. This means studying my own organisation and immediate work setting. My role as a researcher and, at the same time, a KM employee is strictly regulated through written contracts with KM, TK, NRC, and NTNU to avoid possible conflicting goals during the project period. To acquire funding for the scope of the project, methods for collecting data and access to organisations as well as research ethics have been agreed upon and signed by all parties before the work started.

The clear structure and goal of the project have been helpful, but it is necessary to reflect on the less formal aspects of my role and how that may impact my knowledge. A priori

understandings are an inherent part of being part of an industry. I am aware that my close relation to the field may influence my ability to keep an open mind and shape my interpretations; this awareness is necessary to counteract researcher bias. Attempting to recognise the possible pitfalls of being familiar with the research field and being open about my background has been important and necessary as the project has moved forward. Humans make interpretations while attempting to understand the world around them all the time. The interpretations are always made in a context of social beliefs, practices, and traditions. It is not possible for a scientist to escape the contextual aspects of the social situation in which the research is taking place. According to Lincoln and Guba (1986), all human behaviour is time and context bound; the *truth* that scientists uncover is only true in relation to a given, specific situation. Charmaz (2014: 320) emphasises that ‘researchers are part of what they study, not separate from it’. Denzin and Lincoln (2018: 12) regard research as an ‘interactive process shaped by one’s personal history, biography, gender, social class, race, and ethnicity and those of the people in the setting’. This brings me as a researcher into the research situation and process of inquiry rather than as someone who stands on the outside looking in. The research process must therefore be regarded as a social performance where the result depends on the interpretive interaction between me as a researcher and the informants. The positive effects of my background, to a large extent, have outweighed the possible disadvantages. Familiarity with the maritime industry helps in building in-depth understandings and has given me easy access to the field and rich empirical material.

Research ethics is important in any research. The ethical guidelines defined by the National Committee for Research Ethics in the Social Sciences and the Humanities (NESH) have been followed. Required notification about the data collection was sent to and approved by the Norwegian Centre for Research Data (NSD project no. 48687).⁹ The recorded data and field notes are stored and handled in accordance with the Norwegian Personal Data Act. The anonymity of the informants is ensured by leaving out all the names of the people and the workplace in the published material. All interviewees were informed about their right to withdraw at any time and that transcripts and notes would be anonymised and under no circumstance shared by their or my employer.

⁹ Copy of the NSD notification is found in the Appendix.

4.2 RESEARCH STRATEGY AND DESIGN

A research design can be described as 'a structure that guides the execution of the research method and the analysis of the subsequent data' (Bryman 2012: 45). The different components of the study are planned and executed to address the problem statement and research questions presented in Chapter 1. This serves as a flexible guideline where the theoretical framework is connected to the inquiring strategy as well as the methods for collecting empirical data (Denzin and Lincoln 2018). The research has an explorative character (Stebbins 2001) where the scope is to search for generalisations giving a detailed and profound understanding of maritime leadership and the leadership training of professional deck officers.

Stebbins (2001) highlights *flexibility* and *open-mindedness* in the process of exploring a social phenomenon. The research applies a qualitative design where data is collected in a flexible manner, allowing for adjustments as the project moves forward. According to Denzin and Lincoln (2018: 10), 'qualitative research involves an interpretive, naturalistic approach to the world'. This means that as a researcher, I aim to follow their recommendation to study things in their natural settings and attempts to make sense of phenomena in terms of meanings people bring to them (ibid.). This approach is in accordance with the theoretical framework presented in Chapter 3. The overarching perspective of the project is that human actions are socially situated and that knowledge is constructed through social interaction (Berger and Luckman 1966). This theoretical approach forms the basis of the study and the research strategy.

The project intends to generate knowledge of practical importance, especially for actors within the maritime industry. The strategy and design of the study are influenced by the goal to perform research emphasising practical action and usefulness of the work in relation to safety leadership in a maritime context. Guthrie divides (2010: 5) social research into four different categories: pure, applied, policy, and action. According to his model (Figure 5), this study does not fall into the category of pure research, where the scientific outcome is solely of interest to the scientific community. Nor can it be described as policy or action research since the scope does not relate to the improvement of specific practices or support decision

makers but has a more explorative character. The project emphasises topics with a potential for practical application and can thus be categorised as applied research.

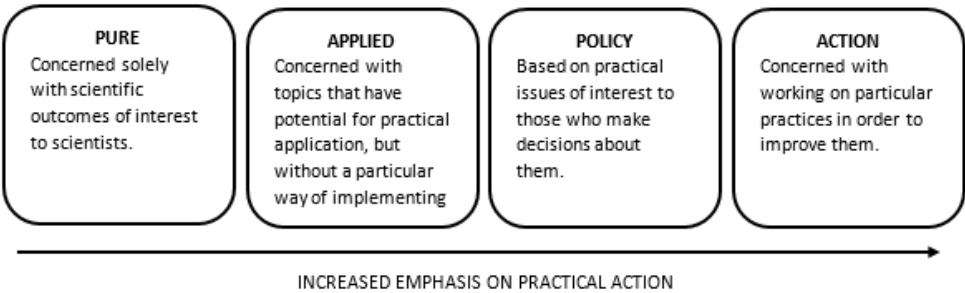


Figure 5 Typology social science research.

With an emphasis on practical matters, the project assumes a pragmatic approach. The research strategy is based on what has been practical, possible, and best suited to explore the research topics. Pragmatism is characterised by an emphasis on humans as agents and knowledge as a social product dependent on interaction and context (Delanty and Strydom 2003). This implies that ‘the meaning of a concept should be regarded in connection with possible practically relevant situations and thus with reference to possible action’ (ibid.: 280). This means an in-depth situational understanding of maritime leadership as well as identifying the practical consequences for the leadership training of maritime professional officers. A comprehensive understanding of the contextual aspects of maritime leadership requires what Charmaz (2014) describes as *rich data* and a need to collect empirical material from as many relevant sources as possible. It also means seeking *thick descriptions* (Geertz 1973) and understanding individuals’ actions with reference to cultural context. Cultural facets in maritime leadership relate to various factors, including nationality, professional background (e.g. as navigators or engineers), organisational belonging (e.g. company or fleet), and any subculture created in the interaction among these factors. Knowledge about the contextual and structural aspects of the seafarers’ working lives, as presented in Chapter 2, has been necessary to better understand, analyse, and theorise about leadership at sea.

4.3 DATA COLLECTION

Qualitative field studies and interviews with 91 persons form the empirical basis of the study, but it should be noted that ‘all research is interpretive – guided by a set of beliefs and feelings about the world and how it should be understood and studied’ (Denzin and Lincoln 2018: 19). The previous research presented in Chapters 1 and 3 should be regarded as an interpretive framework that has guided the research process. The second research question was investigated through a rapid systematic literature review looking for different non-technical skills frameworks and training principles relevant for CRM training in the maritime industry. The search procedure is described in more detail in the second article (see Appendix). The other questions were studied empirically using data from observations and interviews. This section provides an overview of the empirical material and the data-gathering process. A more detailed description of the material is given in each of the published works.

The research strategy is of an abductive character, where the research moves ‘back and forth between a set of observations and theoretical generalizations’ (Tavory and Timmermans 2014: 4). It is a creative process, with elements of surprise that include an ongoing construction of meaning to make sense of the data (Tavory and Timmermans 2014; Alvesson and Kärreman 2011). It consists of four intertwined activities (Tavory and Timmermans 2014): (1) reading a broad range of theories to identify the theoretical framework of the work; (2) participating in a researcher community to broaden the understanding of the field; (3) gathering empirical data; and (4) working systematically with the available information.

The study followed a deliberate sequence where empirical material was collected in the work context of maritime leaders before the training context was investigated. This was deemed necessary to acquire an in-depth understanding of life at sea before addressing the training issues. The material was purposively sampled with the research question in mind (Bryman 2012). The sample size was not predetermined but followed the principle of saturation (Charmaz 2014). When no new insights or patterns were uncovered and data was judged as robust, the data gathering was concluded. Table 5 gives an overview of the empirical material. Observational data and interviews are the primary information sources, while supplementary data is used to gain an in-depth understanding of the field. The different data sources are described in more detail below.

Table 5 Overview of empirical material

	RESEARCH QUESTION 1	RESEARCH QUESTION 3	RESEARCH QUESTION 4
When	Jun.–Nov. 2016	Feb.–May 2018	Sept.–Nov. 2018
Observational Data	<p>Observations 3 ships - 8 days at shuttle tanker in North Sea - 13 days at shuttle tanker in North Sea - 12 days at oil tanker in South China Sea</p>	<p>Observations 2 training programs - 5 courses of generic DP training - 2 courses of custom-made DP training</p>	<p>Observations 2 training programs - 3 courses of generic offloading - 3 courses field of specific offloading</p>
Interview Data	<p>50 interviews with tanker crew - 13 senior officers - 18 junior officers - 19 other crew members</p>	<p>22 interviews with course participants - 16 senior officers - 6 junior officers</p>	<p>19 interviews with trainer/trainees - 12 DP instructors - 7 course participants</p>
Supplementary Data	International legislations; trade requirements; procedures and job descriptions; accident reports; relevant company information	Training requirements of DPO; course material; general information on DP technology; procedures and job descriptions	Training requirements of shuttle tanker DPO; course material; general information on offloading operations; procedures and job descriptions

4.3.1 Observations

The observations were an important source of information in this study and a means to understand the work and training context of maritime officers. They offer a flexible approach to collect data that may contribute to emergent rather than pre-existing knowledge. I collected information about maritime leadership in general at the vessels and about the training of professional officers at the onshore training centres. Relevant data was captured in field notes.

The visits to three vessels offered insight to the lifeworld of mariners and an understanding of the leadership context. Here, informal direct observations were the primary data source. Two of the vessels were shuttle tankers, with the offshore tank fleet commissioned in the North Sea, where the ships offloaded oil from offshore installations and transported it to shore

facilities or other tank boats. The third vessel belonged to the conventional tank fleet, transporting oil mainly among different onshore facilities. It sailed in the South China Sea at the time of the visit. Observations of the daily work aboard and informal conversations with everyone on board gave information about the work practice and formal and informal social relations among the crew as well as the multifaceted dimensions of group interactions taking place at a ship. Time spent at the different ships were 8, 13, and 12 days, respectively. Formal interviews were conducted at the ships mainly to clarify and gain more in-depth understanding of what was observed.

The observations at the training centres were performed intermittently in two periods in 2018. Different training programs were purposively sampled (Bryman 2012) to investigate research questions 3 and 4. Several training sessions in different courses were observed. Observational data was complemented by formal interviews and informal talks. At the vessels, everybody on board was aware of my presence as a researcher, while at the training centres, I blended in more and could observe the training covertly. Most of the observations at the training centres were also of a participatory character because of my part-time role as an instructor with the investigated company.

4.3.2 Interviews

The interviews were based on discoveries from the observations and gave an opportunity to collect more focused information (Stebbin 2001). They served as a tool to clarify and gain a better understanding of observed behaviour at the vessels and the training centres as well as gave more specific information in relation to the research questions. The interviews were semi-focused and semi-open-ended and were based on the course participants' direct experience with the research context, focusing on the subjective experiences of the informants. The interviewees are called *informants* rather than *respondents* because they not only offered their opinions about specific questions but also provided general insight to maritime leadership and training.

The questioning in the interviews was informal, and the phrasing as well as the sequence of the questions varied from interview to interview. The interviews were semi-structured.

Separate interview guides were developed reflecting each of the research questions.¹⁰ These were used to help structure the talks with the participants. The questions were not of a sensitive character, and the trust of the informants could be gained either in advance or at an early stage in the interview, both at the vessels and at the training centres. This allowed for short talks in line with the concept of focused interviews (Tjora 2018; Merton and Kendall 1946). Most interviews lasted between 15 and 30 minutes; some of the interviews were with two or three people at the same time and thus lasted longer. Interviews with senior officers at the vessels and the instructors at the training centres were of a more explorative character and lasted between 30 and 60 minutes.

The 22 interviews with course participants related to research question 3 were audio-recorded and subsequently transcribed. Most of the other interviews were not audio-recorded. The background noise on vessels (engine sound, alarms, vibrations, etc.) reduced the quality of the audio recordings, therefore making the recordings a tool of limited help in capturing data. Many interviews were done in English. Since this was not the native language of any of the informants, many struggled to give oral descriptions that would be understandable when transcribed word by word. Instead, the intended meaning was achieved using body language or a more figurative language where the meaning was best captured in the moment and noted during the interviews. My access to the field and the informants for long periods also allowed for a chance to ask clarifying questions after the formal interview should my notes be unclear. Most interviews were done face-to-face, except for those with five DP instructors, who were interviewed on Skype.

4.3.3 Supplementary data

The empirical material includes supplementary data, which consists of documents or information that has not been produced because of my research, such as field notes or transcribed interviews (Bryman 2012). This is information gathered from a broad range of different official documents, for example procedures and job descriptions, international legislations and requirements relevant to the line of trade, and training material. An overview of the most relevant documents is given in Table 5. This information has been valuable and necessary before, during, and after sessions with observations and interviews. To carry out

¹⁰ Examples of interview guides are included in the Appendix.

the interviews or to understand what was observed without basic knowledge about technology – for example, the DP and other ship systems related to the studied work processes – would have been difficult. To have knowledge of maritime terminology and key regulations has been helpful in establishing an overall understanding of the field.

4.4 ANALYSIS

To transform the data from the everyday worlds of the mariners into research results on wider phenomena in the research questions, the data was analysed and interpreted systematically, with a focus on finding patterns and explanations in the empirical material (Coffey and Atkinson 1996; Tavory and Timmermans 2014). The work is characterised by a dynamic interaction between data and theory in an abductive manner, combining inductive theorising based on empirical data and deductive empirical theory testing (Coffey and Atkinson 1996). This means the analysis is performed as an iterative process, moving back and forth between empirical material and theoretical generalisation in an ongoing construction of meaning (Tavory and Timmermans 2014). The analysis process starts when the data is collected, and this understanding shapes and aids the subsequent steps in the data-collection process. The data is coded and organised first at a general level, giving an overview of the material. Then more detailed codes are used to expand and add new levels of interpretation in an interwoven process of analysis characterised by the comprehensive searching and systematic scrutiny of the available data (Coffey and Atkinson 1996).

Much of the analysis happens naturally while writing notes from the interviews and the observations. Here, the first decision on what counts as relevant information is made. It is possible to claim that some of the data is analysed and reduced already at this stage, even if my intentions are to note down as much as possible freely to ensure a broad understanding. The data is then displayed as transcript files and investigated further in the research process. Each paper and related research question requires that the written material be revisited, reanalysed, categorised, and coded in an iterative manner. The data is reduced, analysed, and interpreted several times (Coffey and Atkinson 1996) to find patterns in the empirical material. Broad topics are identified initially, and then the material is coded and categorised in an iterative process between the empirical data and the applicable theoretical perspectives. The principle of saturation (Charmaz 2014) is applied in this process. When no new insights or

patterns are uncovered, and the established categories are judged as robust, the data gathering is concluded. The data analysis is not assisted by any specific software tool; I prefer to organise and structure the material in tables by the help of standard Microsoft products (Word and Excel) to attain an overview of codes and categories.

Abduction depends on the *interplays of observations* and the way that *the researcher's socially cultivated position* (habits and thoughts of action) shapes the interpretation process (Tavory and Timmermans 2014: 41). This means that my background influence how I see the world and what I look for. My ability or inability to set the data material into theoretical frameworks or be surprised by what was found has been influenced by prior theoretical knowledge as well as new knowledge acquired in the research process. The *creative inferential process* (Tavory and Timmermans 2014: 5) has primarily been shaped by my scientific knowledge, but it is also necessary to reflect on other aspects of my personal background. My familiarity with the maritime domain ahead of the study and how this may have influenced the research process are discussed in the beginning of this chapter.

4.5 RESEARCH QUALITY

Common criteria to test research quality in many studies are (1) *internal validity*, evaluating the truth of the inquiry, (2) *external validity* or evaluating the generalisability of the study, (3) *reliability*, evaluating the replicability or consistency of the research, and (4) *objectivity*, evaluating the neutrality and possible bias in the study (Bryman 2012). These four criteria are not always directly applicable to qualitative research (Denzin and Lincoln 2018; Bryman 2012; Lincoln and Guba 1986). Lincoln and Guba (1986) suggest assessing qualitative studies in accordance with the principle of *trustworthiness*, which includes these four criteria but applies the parallel concepts of (1) *credibility*, (2) *transferability*, (3) *dependability*, and (4) *confirmability*. These four criteria are used to evaluate the scientific quality of the work.

'Credibility refers to whether a researcher can gain an accurate or true impression of the group, processes, or activity under study' (Stebbins 2001: 48). There are three possible problems related to this in explorative studies: the effects of the presence of the researcher, the selective perception and interpretation of the researcher, and the limitations of the researcher's ability to witness all relevant aspects of the phenomenon in question (ibid.). To meet these possible problems, the author has taken various measures based on the

suggestions of Lincoln and Guba (1986: 18–19). Lengthy visits to three vessels allowed for intensive (24/7) contact with informants and a prolonged engagement with the field. Being employed with KM allowed frequent observations of a broad range of various training programs and close contact with the informants over time. This gave the opportunity for persistent observations and the in-depth pursuit of the training programs relevant to the study. Empirical material that contained information from observations, interviews, and the broad range of supplementary sources enabled a cross-checking of data. This also included the continuous and informal testing of information during interviews and informal talks with informants, where I reconstructed what had been observed or told by others. Since I was the sole investigator throughout the project, the supervisors were important discussion partners who assisted in developing a firm research design and working hypotheses. These discussions, along with peer reviews related to the publication processes of the scientific works, can be regarded as helpful tools to ensure the credibility of the study.

Transferability means evaluating the possibility of applying the findings elsewhere, to other cases or different contexts (Lincoln and Guba 1986). It can be compared to external validity and ‘whether the results of a study can be generalized beyond the specific research context in which it was conducted’ (Bryman 2012: 711). Lincoln and Guba (1986) state thick descriptive data is necessary to judge whether the finding may be applicable elsewhere. I have pursued thick descriptions (Geertz 1973) of the research context and the findings to ensure transferability. Gathering rich data (Charmaz 2014) has been an important aspect of the work, and the combination of observations, interviews, and use of supplementary data in the research design has enabled a sensitivity to context. This includes providing characteristics of the sample, the ship, and the training context as well as the work and training processes. It should be noted that the findings are my interpretations of various actors’ experiences with maritime leadership and simulator-based training.

Dependability, as a parallel to reliability, can be established by ensuring that complete records are kept of all the research phases and that these are made accessible to others (Lincoln and Guba 1986). Dependability in this thesis has been ensured by describing the background and the overall objective of the research, presenting the four research questions and the methodology used to explore them. My role as a researcher is explained, and possible

challenges are explored in Section 4.1. Section 4.2 reveals the research design and sets out to give other researchers an opportunity to evaluate the replicability or consistency of the study and to judge the criteria of dependability. Records of the empirical material have been kept throughout all phases of the study. A weakness is that I have been the sole researcher collecting the data. The initial analysis of the material has been done by me alone, but as part of the writing process, co-authors have given their input to the analysis process, except for the one paper where I was the sole author. The supervisors have been actively participating in the entire research process, and their role may be described as the auditors of the project. The review process of the individual papers also applies the auditing approach suggested by Lincoln and Guba (1986) to ensure reliability.

Confirmability parallels the objectivity criterion (Lincoln and Guba 1986). Complete objectivity is impossible in qualitative research, but the researcher should demonstrate that they have acted in good faith and have not allowed personal values or theoretical preferences to influence the research unduly (Bryman 2012). Section 4.1 discusses my possible biases related to the criteria of confirmability. I have aimed to act in good faith and to avoid any possible bias as a researcher with extensive prior knowledge of the field to be studied. I found my background to be an advantage that helped me gain access to the field and to draw thick descriptions of both the leadership and the training contexts. Familiarity with the field helped during interviews as it was easier to understand technical terms that would have been difficult to grasp without prior understanding. This knowledge enables sensitivity to what the informants are saying or what is observed. The drawback of prior knowledge may be preconceptions, but I have been aware of this throughout the process and has tried not to let this colour how I interpret what was said or done by the informants. To counteract biases, the research results were discussed with other parties: the participants of the study as well as colleagues and supervisors.

5 OVERVIEW OF RESULTS

This work sets out to investigate maritime safety leadership and explore how bridge simulators can be used to train professional deck officers. This chapter briefly presents the four papers included in the thesis. The complete texts are found in the Appendix. The work is summarised to give an overview of the study results, to present the links among the works, and to describe how they shed light on the four research questions. Table 1 in the introduction gives an overview of the scientific works, how they are linked to the research questions, and their main data sources. Each of the papers is designed to answer one specific research questions, but the separate scientific works also contribute to an overall understanding of the social aspects of maritime safety leadership and the training of deck officers.

5.1 BALANCING LEADERSHIP STYLES

The first paper shows how a combination of transformational and transactional leadership styles is described as good leadership by mariners and understood as beneficial for the safe operations of a ship. It highlights what can be considered good leadership in a maritime context and discusses the importance of such a leadership style in a safety perspective. It is based on observations at three tankers and interviews with 50 crew members on these ships regarding leadership. What characterises good leadership at sea is a relatively uniform view among the seafarers. The crew spend much of their time with their colleagues; thus, life on board is compared to family life, and some of the same social factors at home come into play on board. The captain is described as the head of the family, and his authority is based on both his professional expertise as a mariner and his ability to show respect and care for others. The ability to balance assertiveness and friendship is regarded as an important skill. Good leadership is often described as teamwork, indicating that the officers need to show trust, delegate work tasks, and listen to the crew. The officers are expected to be visible role models who participate in the work, who set clear goals and actively correct safety-critical behaviour. Technical expertise and knowledge of work on board are regarded as prerequisites to carry out leadership responsibilities, to be aware of possible risks, and to make reasonable decisions.

Many of the elements mentioned above are hallmarks of transformational leadership (Bass and Avolio 1994), for instance creating team spirit, listening, delegating tasks, mentoring, and caring for the crew. At the same time, the results indicate certain aspects of a transactional leadership style that is regarded as beneficial and crucial to safety. It is both expected and appreciated when officers emphasise strict compliance with the safety management system and correct or discipline violations to rules or procedures. Active management by exception (Bass and Riggio 2006) can thus be a crucial element in safety leadership in high-risk organisations such as shipping companies. The data material demonstrates that the two leadership styles are not mutually exclusive as in the original model (*ibid.*); rather, different components of both a transformative and a transactional leadership style are needed to maintain high reliability. Seeking advice, relying on expert opinions, setting a clear standard for safety violations, and encouraging the crew to detect and report possible risk are all factors that may help build and maintain a resilient organisation (Weick and Sutcliffe 2007). Thus, balancing the two leadership styles can be an important prerequisite for safe operations and appears as an essential characteristic of safety leadership.

5.2 MARITIME OFFICERS' ESSENTIAL LEADERSHIP SKILLS

The second paper discusses what non-technical skills maritime officers need and how these can be learned. The article is a literature review of recent empirical research on CRM training in the maritime industry. The literature review demonstrates that much of the research related to CRM training is dominated by individualistic theories of learning, with less focus on learning as a social process. The article explores maritime CRM training from a social learning perspective to close this knowledge gap. The work assumes that learning is a context-bound and social process that occurs in communities of practice such as a crew. It is argued that a social view on learning can contribute to broadening the scope of CRM training in the maritime industry. The work highlights that CRM training should be tailored to specific crews, aiming for a learning environment as close to reality as possible. The work identifies applicable factors relevant to the CRM training of maritime officers. Five categories of essential leadership skills are identified in Table 5 (Wahl and Kongsvik 2018: 391).

Table 6 Taxonomy of non-technical skills of maritime officers

CATEGORY	ELEMENTS
Situation Awareness	<ul style="list-style-type: none"> - Be aware of ship's systems - Be aware of external factors - Collect relevant information - Identify dangers
Decision Making	<ul style="list-style-type: none"> - Identify risk - Assess options - Select options and plan action - Review outcomes
Communication	<ul style="list-style-type: none"> - Ask questions - Share information - Listen and respond to concerns - Give feedback
Team Coordination	<ul style="list-style-type: none"> - Be aware of team condition - Consider team experience - Coordinate and delegate tasks - Care for and support others
Assertiveness	<ul style="list-style-type: none"> - Provide and maintain standards - Take initiative - Set clear goals - Be concise

The taxonomy gives an overview of what maritime officers need to learn according to the analysed material and indicates the magnitude of the concept of non-technical skills and the complexity of CRM training. Each category comprises different components that can be adapted to different operation-specific needs in a training program. The importance or emphasis of each category may vary depending on the training needs identified. It is suggested that these categories be further developed, divided into different elements, and detailed into behavioural markers indicating important skills relevant to individual teams and their work situation. Current training seems to be suffering from training programs that are exported 'as is' from aviation and not adjusted to the maritime domain or to operation-specific needs. This underlines that the taxonomy should be regarded as a tentative framework that must be translated and adjusted for the technical and social context that characterises the work environment of the officers undertaking the training.

5.3 SOCIAL FIDELITY IN SIMULATOR-BASED TRAINING

The third paper coins the term *social fidelity*, describing the significance of social processes in the simulator-based training of professional deck officers. This is a theoretical contribution where the term bridges the gap between computer technology and collaborative learning activities in the simulator-based training of maritime officers. It is based on observations of two different simulator programs for professional maritime officers and focused on interviews with bridge officers participating in the sampled training. The study explored how learning unfolds in a simulator-based training context characterised by the extensive use of advanced computer technology and collaborative activities.

The concept of simulator fidelity has usually been limited to the technological aspects of simulator training with an assumption that a high level of fidelity equals a high physical resemblance between a simulator and the real work environment. The objective of this article was to expand the prevailing understanding of the concept and investigate how social factors influence perceived training quality among professional maritime officers. The analysis demonstrated how technical and collaborative factors interact and contribute to an overall level of perceived fidelity and training quality among professional maritime officers.

The work emphasises that physical and functional fidelity are important but must be considered in relation to what characterises the tasks to be solved during the simulator sessions. Rather than being the only aspect of simulator fidelity, simulator technology serves as a necessary backdrop for creating lifelike tasks in a collaborative environment. This study shows how task and social factors are essential in creating a realistic training environment. It indicates that the exact replication of the physical entities of a bridge is not always necessary to realise training goals; rather, it emerges in the interactions among the simulator, the course participants, and the instructor. The simulator offers a necessary backdrop for realistic tasks but is not a sufficient condition for learning.

The article introduces the term *social fidelity* to explain how social factors contribute to simulator-based learning. Three aspects are highlighted – (1) the opportunity to visualise practical drift and establishing safe work practice through peer and instructor feedback, (2) the use of storytelling to share experiences and learn from one another, and (3) the function of social rank in a training setting. This indicates that social fidelity may influence the overall

level of experienced fidelity. The joint collaborative activities among the trainer, the trainees, and the task at hand may enhance perceived training quality beyond technical aspects. The work recommends that the interactions among these three factors and between social fidelity and simulator technology be considered when designing simulator-based training sessions.

5.4 TRAINING TO MANAGE SAFETY AND PERFORMANCE VARIABILITY

The last paper explores how the simulator-based training of professional maritime deck officers can improve the management of performance variability and safety during critical operations at sea. The research is based on observational data from two different DP training programs and interviews with simulator instructors and experienced mariners attending these programs. RE is used as the theoretical framework, with an emphasis on performance variability and learning.

The operator's ability to control variability depends on their ability to anticipate, monitor, and respond to system errors. These abilities are the core of resilience skills. The data illustrates three key skills in learning to manage variability: the ability to prevent adverse events by recognising anomalies and solve problems in a flexible manner; the ability to define the limits of action through shared knowledge; and the ability to operate the system with confidence. These can also be understood as important skills in safety leadership. The results indicate that deck officers learn these skills through joint reflection among professionals and experiential learning triggered by realistic simulator exercises. It is important to note that the analysis shows that realistic training should not be limited to a focus on adverse events and emergency handling but must also include mundane tasks and minor errors so that operators can learn to catch and contain minor errors before they evolve into uncontrollable situations.

The empirical material demonstrates how the simulator-based training of professional deck officers can be used to manage performance variability but should not be regarded as automatic results. These are possible effects of a training philosophy designed to address the balance between Safety I and Safety II. The study demonstrates that a history of failure works as a repository for highlighting and improving the skills and confidence needed to deal with situational complexity and to maintain operational variability; thus, realistic and effective training requires balancing Safety I and Safety II knowledge.

This study shows that Safety II, to a large extent, builds on operators' ability to train their resilience skills. The advantage of regarding resilience as a skill is that it becomes more tangible and something an organisation can achieve by training key personnel. This analysis indicates that managing performance variability is an important aspect of safety leadership at sea.

6 DISCUSSION

The purpose of this work is to contribute to the understanding of safety leadership and investigate how bridge simulators can be used to train deck officers. The thesis contains four independent papers that are the basis of the work, and each paper relates to one specific research question. The discussion synthesises and reflects on these four scientific works. It starts by discussing safety leadership as a balancing act, followed by examining adaptability as a leadership skill, and considers the importance of social fidelity when training deck officers in safety leadership.

6.1 SAFETY LEADERSHIP AS A BALANCING ACT

Safety leadership can be understood as a process that handles the important formal and informal functions, tasks, roles, and responsibilities when maintaining safety in an activity or an organisation (Kongsvik et al. 2018). The term ties together the formal and informal aspects of leadership and points to the importance of coordinating and controlling work as well as maintaining social processes and psychological dimensions that may influence safe work performance. The view emphasises that an officer needs to adjust their leadership to both informal factors and formal requirements to run the ship in an efficient and safe manner. This can be described as a balancing act between formal requirements and informal factors, visualised in Figure 6.

The senior officers at tankers are responsible for ensuring that work on board is carried out in accordance with international and national regulations. This gives a very distinct set of formal requirements on how to coordinate and control the work. As described in Chapter 2, the ISM Code dictates that a shipping company must have a safety management system in place and that the ship master is responsible for the work being performed accordingly. The intention of safety management systems is to make work transparent across context and provide a standard for safe operation applicable to the industry in general. The drawback is that it may limit necessary variation and hinder adjustment to local characteristics (Almklov et al. 2014).

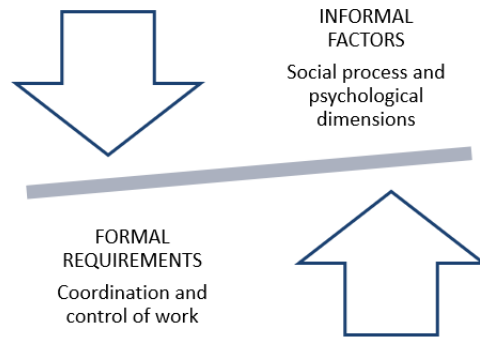


Figure 6 Safety leadership: Balancing formal safety requirements and informal factors.

Supervising performance and promoting compliance with rules and procedures are described as the core activities of transactional leadership (Bass and Riggio 2006). The data material uncovers aspects of a transactional leadership style that is regarded as beneficial and crucial to safety. It is both expected and appreciated when officers clearly state their expectations of the job performance and use praise or awards to encourage safe work practices (*contingent reward*). It is also appreciated that the officers actively monitor crew performance and expect strict compliance with the safety management system and proactively correct or discipline violations to rules or procedures (*management by exception — active*). The transactional leadership style is in line with Hale and Borys's (2013a) *model 1* paradigm on how rules are perceived and managed in an organisation. This can be regarded as a top-down rational approach to leadership where written rules are static, comprehensive limiters of choice imposed on the crew and where violations are regarded as negative behaviour to be suppressed. The procedures are transparent and explicit but leave little room to user discretion and competence. In routine work conducted by low-skilled people, this approach is often regarded as an advantage (ibid.). This is the dominant paradigm in shipping.

Following Rasmussen (1997), an officer's space of possibilities and degree of freedom is influenced by the boundary of unacceptable workload, the boundary of economic failure, the boundary of functionally acceptable behaviour, perceived safety culture, and management pressure towards efficiency. To control system performance and risk, he says that focus should be on making the boundaries explicit and known and developing people's coping skills rather

than enforcing behaviour following a pre-planned static structure. Rasmussen (ibid.) claims that risk management in a modern, dynamic society must consider the constant changes and cannot be applied at a general level but must be analysed, evaluated, and adjusted for each specific system. This corresponds with the *model 2* paradigm proposed by Hale and Borys (2013b), involving three basic assumptions: (1) rules are underspecified and can never cover all eventualities; (2) variations and the adaption of human performance are valuable and necessary, and (3) experience-based, professional judgement is fundamental for safety. They claim that rules and procedures must be adapted to the reality of the situation in which the work takes place. Rules are designed using a bottom-up approach and regarded as dynamic and local where the users' competence is seen as an asset enabling a constant adjustment of the rules to operational context. The *model 2* perspective should be used in complex operations with high uncertainty and risk and where improvisation may be needed. Hale and Borys (2013b) do not dismiss rules and compliance to these but highlight the need to combine both *model 1* and *model 2* in modern organisations. This is particularly relevant to the complex work at a shuttle tanker, where procedures are the backbone of all work but where managing performance variability is crucial during DP operations and where experience-based professional judgement is fundamental for safety.

The interviewed officers and simulator instructors unanimously agreed that 'doing things right' is not the same as 'blindly following procedures'. Several officers pointed out that even if DP operations are highly regulated and the procedures governing the work are detailed, the DPOs need to use professional judgement to perform the job in a safe manner. This means not only controlling and coordinating the work in a transactional manner but also employing some personal judgement related to the situation at hand based on available information. An officer's ability to have a situational overview and to fit this knowledge into a mental model to understand what is happening and how to best control the situation is described as *situation awareness* (Endsley 1995). This is essential to operate the ship safely and to make sound decisions (Saeed et al. 2017; Sandhåland et al. 2015; O'Connor and Long 2011). It is accomplished by collecting relevant information and being aware of ship systems and external factors that may cause dangerous situations. Communication is at the heart of this. The non-technical skills framework presented in the first paper emphasises asking questions, listening

and responding to concerns, and giving feedback as part of the communication strategy for officers. This is not possible without *intellectual stimulation*, encouraging the crew to share relevant information and suggest improvements. At the same time, it is necessary to continuously monitor crew performance and discover weaknesses in the system or among crew behaviour that may escalate into serious incidents by applying *management by exception (active)*.

Providing and maintaining standards, taking initiative, setting clear goals, and being concise are important in maritime leadership. These may be understood as transactional behaviours, but it is necessary to add some nuances to this picture. Wu et al. (2015) highlights that an officer needs to state decisions in a confident manner but, at the same time, be able to communicate sincerely and equally with others, to issue instructions and simultaneously motivate crew members. This is supported by Saeed et al. (2017), who describe how an officer needs to demonstrate a proper amount of autonomy and assertiveness, balancing full control of the situation with an ability to listen to the crew and involve them in planning and be open to their suggestions, at the same time ensuring that limits of acceptable behaviour and task performance are clearly communicated.

Coordinating and delegating tasks may be done in a transactional manner. Clear orders are essential to the safety of the ship and the crew (O'Connor and Long 2011), but an officer must also consider the overall experience and condition of the crew to delegate tasks to the right person at the right time. This knowledge can only be achieved through caring for and supporting individual crew members. The importance of caring is emphasised in the interviews with officers and crew at the visited tankers. Team building, consideration for the conditions of other crew members, and personal feedback are highlighted by Saeed et al. (2017). This fits with the description of *individualized consideration* (Bass and Riggio 2006). The ability to act as a mentor or a coach, listen to individual needs and provide support, and give subordinates new challenges so that they can experience personal growth is also highlighted in the data material.

Several studies indicate that a combination of transformational and transactional leadership tactics may be beneficial for safety (e.g. Kim and Gausdal 2017; Glendon and Clarke 2016; Clarke 2012; Griffin and Hu 2013; Clarke and Ward 2006). Glendon and Clarke (2016) argue

that the two kinds of leadership should be regarded as complementary and that the chosen practice should depend on the situation. In work situations characterised by a high degree of routinisation, they suggest that transactional leadership would be the most appropriate style, whereas when routinisation is low, transformational leadership is more suitable. This thesis demonstrates how different components of both transformative and transactional leadership are needed to maintain safety. This is evident in both the literature review and the empirical material from visits to tankers. The data indicates that to distinguish between daily leadership during regular operations and leadership in a critical situation is necessary. A non-normal situation requires that the crew comply with the established emergency procedures, and the role of the master is to monitor the situation and correct actions immediately. A transactional leadership style may be appropriate to maintain safety in this situation. At the same time, it is impossible to anticipate what may happen; rules can never cover all eventualities and possible actions (Hale and Borys 2013b), and the crew may need to improvise. A transformative leadership style in everyday life can create the basis for this ability to handle unforeseen disturbances to the system. Daily leadership characterised by individual support, delegation, and emphasis on personal growth can represent a basis and a starting point for managing more critical situations. This is evident in the story about the polar explorer Ernest Shackleton (Morrell and Capparel 2001). His efforts to build companionship, loyalty, responsibility, determination, and optimism among his men in the early days of the expedition were an important reason as to why they had managed to cope with the crisis and survive for two years in Antarctica. It is generally accepted that leadership is not a static phenomenon; leaders may change behaviour from one situation to another (Hersey and Blanchard 2013). When exposed to high levels of demands, for example, in safety-critical operations, it is likely that a leader will prioritise task-centred behaviour (Nielsen et al. 2016).

Seeking advice, relying on expert opinions, setting a clear standard for safety violations, and encouraging the crew to detect and report possible risk are all factors that may help build and maintain a resilient organisation (Weick and Sutcliffe 2007). Balancing transactional and transformational leadership appears to be a central aspect of safety leadership. This includes not blindly following procedures but being able to adapt them to the reality of the work situation. This demonstrates that the ability to control and coordinate the work on board in

accordance with formal requirements while making adjustments based on social and psychological factors is central in safety leadership. The following chapter looks at what deck officers must do to succeed with this balancing act.

6.2 ADAPTABILITY AS A SAFETY LEADERSHIP SKILL

If we regard maritime safety leadership as a balancing act, what skills are needed for deck officers to carry out their jobs effectively? The literature review identified five skill categories related to maritime leadership: *assertiveness*, *decision making*, *communication*, *team coordination*, and *situation awareness*. The empirical material from deck officer training shows the importance of *resilience skills* (Saurin et al. 2014) when operating the DP system at shuttle tankers. Three aptitudes were found to be central to control variability in this study: the ability to prevent adverse events by recognising anomalies and solve problems in a flexible manner; the ability to define the limits of action through shared knowledge; and the ability to operate the system with confidence. These can also be understood as important skills in safety leadership. The discussion above indicates that deck officers, in addition, must be able to adjust their leadership to the people being led and the leadership context.

The *situational leadership model* (Hersey et al. 2013) addresses the importance of the leadership context. The fundamental principle in this perspective is that no single best style of leadership exists. Effective leadership is task relevant, and the greatest leaders are those who adapt their leadership style to the performance readiness (ability and willingness) of the individual or group they are leading. Four basic leadership styles are proposed – directing, coaching, supporting, and delegating. Effective leadership varies not only with the person or group being influenced but also with the function, job, or task to be accomplished. The theory emphasises that the skills and motivation of followers will vary over time and that a leader will need to adjust leadership accordingly. Following this perspective, an officer needs to assess the individual crew member, evaluating how competent or committed they are to perform a job before applying the correct leadership style. This requires three competencies (Hersey et al. 2013):

- 1) *Diagnosing* the situation — It is a cognitive ability that involves understanding what the situation is now and what to expect in the future. This is similar to situation awareness (Flin et al. 2003; Endsley 1995).

2) *Communicating* — It means interacting with others in a way that others can easily understand and accept. Hersey et al. (2013) describe this as a process competency.

3) *Adapting* — It means altering behaviour and other resources available to meet the contingencies of the situation. This is described as a behavioural competency (ibid.) that involves changing both the leader's and the followers' behaviours to get the job done.

The ability of deck officers to adapt to the situation at hand is discussed in the fourth paper about controlling variability and handling situational complexity during DP operations. Borys et al. (2009) point to the notion of variability and the ability to adapt to changes as important aspects of safe operations in modern organisations. They claim that this requires a change in perspective from human variability as a liability and something that should be controlled to an asset in organisational safety. They argue that adaptability is needed because the tendency of high-risk industries to rely on documented safety management systems has some clear limitations. For these systems to work properly and safely, all procedures must always be updated and correct, and all systems must be well designed and continuously maintained. This is not possible in complex organisations. Things go right because people learn to overcome design flaws and functional glitches, adapt their performance to meet demands, interpret and apply procedures to match conditions, and detect and correct errors (Borys et al. 2009: 21). Borys et al. (2009) demonstrate that the need for adaption is low in tractable systems that are simple, stable, and easy to control. Tightly coupled intractable systems such as DP-operated tankers may require constant performance adjustments to operate safely and thus a high level of adaptability. They argue that HROs are *complex adaptive systems* preoccupied with failure to treat any glitches or errors as possible system weaknesses.

It is necessary to differentiate between necessary adaptations and potentially dangerous drift. Pettersen and Schulman (2016) propose the term *reliability drift* to point adaptations that may increase risk. Rules help us control and coordinate work, and when we interact, we assume that others are familiar with and conform to the same rules. Snook (2000) showed how global organisations such as shipping companies are vulnerable to *practical drift*. This refers to a situation where local work practices over time drift away unnoticed from the original, written procedure. It may lead to what Hollnagel (2018) describes as gaps between *work as imagined* versus *work as done*. This may result in a slow but steady separation of local practice from

global procedures. These local adjustments are hardly ever discussed because of their tacit and embodied character. This kind of adaptability may lead to *reliability drift*, where the risk of failures increases because of a loss of risk awareness; ‘people in the organization no longer have an accurate understanding of organizational practices and their effects on the whole system’ (Pettersen and Schulman 2016).

Table 7 Six skills essential to safety leadership

CATEGORY	ELEMENTS
Situation Awareness	<ul style="list-style-type: none"> - Be aware of ship’s systems - Be aware of external factors - Collect relevant information - Identify dangers
Decision Making	<ul style="list-style-type: none"> - Identify risk - Assess options - Select options and plan action - Review outcomes
Communication	<ul style="list-style-type: none"> - Ask questions - Share information - Listen and respond to concerns - Give feedback
Team Coordination	<ul style="list-style-type: none"> - Be aware of team condition - Consider team experience - Coordinate and delegate tasks - Care for and support others
Assertiveness	<ul style="list-style-type: none"> - Provide and maintain standards - Take initiative - Set clear goals - Be concise
Adaptability	<ul style="list-style-type: none"> - Adjust leadership to crew performance - Adjust leadership to task - Adjust rules to operational context - Improvise when needed

The discussion above indicates the importance of adaptability as a leadership skill to maintain safe and efficient operations. Adding a sixth category to the skill taxonomy proposed in the second paper is suggested. Four elements related to adaptability appear essential: (1) the ability to adjust leadership to crew performance; (2) the ability to adjust leadership to task; (3) the ability to adjust rules to operational context; and (4) the ability to improvise when needed. Table 7 gives an overview of the identified safety leadership skills. The next chapter will take a closer look at how to train these skills.

6.3 SOCIAL FIDELITY AS A TRAINING TOOL

The ability to read the situation and adapt leadership accordingly requires technical, interpersonal, and conceptual skills; thus, all three skills must be addressed in simulator-based training programs for professional deck officers. Technical skills are the prerequisite to be able to do the job as a maritime officer; without this, they will not be able to utilise the other skills. These must be regarded as the basis for safety leadership in a maritime context (see Figure 7). Technical knowledge about the vessel and the instrumentation at the bridge is the fundament for situation awareness, sound decision making, and the handling of variation. Without a clear understanding of the technical aspects of the job at hand, coordinating the team, communicating in a manner understood by others, or setting a clear goal and being an assertive leader is impossible.

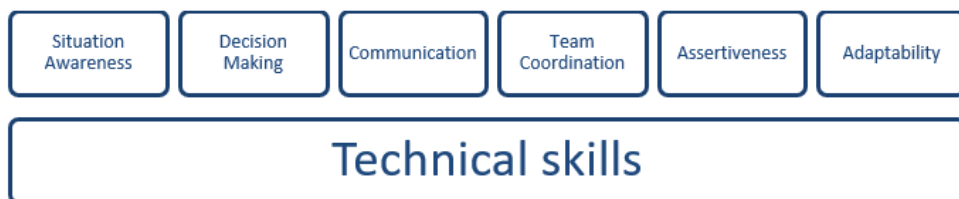


Figure 7 Technical skills as the basis for safety leadership.

The interviews with deck officers participating in simulator-based training demonstrate how technical and collaborative factors interact and contribute to an overall level of perceived fidelity and training quality among professionals. It is the combination of functional, physical, and social processes that ensures high-quality training. This work emphasises that physical and functional factors are important but must be considered in relation to what characterises the tasks to be solved during the simulator sessions. Rather than being the only aspect of simulator fidelity, simulator technology serves as a necessary backdrop for creating lifelike tasks in a collaborative environment. The study coins the term *social fidelity* to describe the importance of social processes in creating a realistic training environment. Three aspects are highlighted – (1) the opportunity to visualise practical drift and establish safe work practice through peer and instructor feedback, (2) the use of storytelling to share experiences and learn from one another, and (3) the function of social rank in a training setting. The work

recommends that the interactions among these three and between social fidelity and simulator technology be emphasised when designing simulator-based training sessions.

The latest version of the STCW convention (IMO 2011) requires all officers to undergo specific leadership and teamwork training. Much of this training is delivered as CRM courses, but it is uncommon to provide this training in combination with technical courses. The empirical material indicates that the primary goal of the studied training programs is technical knowledge and the proper use of procedures and checklists in risk-proven operations. What is interesting to note is that the training also contributes to an understanding of leadership skills. However, this knowledge is less explicit than the technical aspects of the training; it is acquired indirectly and mostly as informal or tacit knowledge. This is a weakness of the current training regimes. Since all professional deck officers attending simulator-based training have leadership responsibilities, this must be addressed in a more direct and explicit manner in future training. Combining technical and CRM training is necessary to develop the required safety leadership skills. With the increase of the level of social fidelity in technical courses, the officers are given a chance to test their leadership skills in a realistic, risk-free environment. This will give the officers a better, more holistic understanding of the socio-technological system they are part of and help them become assets in handling the future challenges of the maritime industry.

7 CONTRIBUTIONS, IMPLICATIONS, AND FURTHER RESEARCH

This thesis aims to contribute to the understanding of safety leadership in a maritime context and explore how bridge simulators can be used to train professional deck officers. The four research questions have uncovered that safety leadership in a maritime context can be described as a balancing act and demonstrated how an officer must adjust their leadership to both informal factors and formal requirements to run the ship in an efficient and safe manner. The main theoretical contributions of the thesis are a taxonomy of leadership skills and the concept *social fidelity*, which have implications for the design of simulator-based training.

The emphasis on social processes in the research has broadened the understanding of leadership skills in the maritime domain and supplemented the prevailing psychological approach to CRM training. Six different safety leadership skills are proposed as essential for deck officers: *situation awareness*, *decision making*, *communication*, *team coordination*, *assertiveness*, and *adaptability*. The strength of the skills approach to leadership is that it is regarded as something that can be learned, but the suggested taxonomy should be regarded as a tentative framework, and the training of these skills must be tailored to situational and operation-specific needs. The practical implication of this is that training programs must be custom-made and that shipping companies must identify their needs and set clear expectations to training providers. The findings also indicate that the training of non-technical skills should be addressed more explicitly in technical training and not only in CRM courses. The importance of situational factors is demonstrated in the study, and their influences on needed skills are emphasised. This indicates that adopting the findings directly to leadership in other settings may be challenging. Future research should be performed on safety leadership in different contexts, not only in the maritime domain but also in other industries.

The thesis introduces the concept of *social fidelity*. The term bridges the gap between computer technology and collaborative learning activities and points to the importance of social processes in simulator-based training. The work recommends that effective simulator-based safety leadership programs balance social, functional, and physical fidelity to create realistic training settings. This implies that the computer technology is essential yet not the only tool in creating high-quality training. The training tasks must be based on real events and mirror the deck officers' daily work. The learning quality is enhanced when the deck officers

share their experiences and give one another feedback. The simulator instructor holds a key role in facilitating an effective learning environment, characterised by realistic tasks, joint reflections, and experiential learning. This must be reflected in future simulator instructors' education.

This work demonstrates that realistic training should not be limited to a focus on adverse events and emergency handling but must also include mundane tasks and minor errors so that operators can learn to catch and contain minor errors before they evolve into uncontrollable situations. The data indicates that simulator training allows for reflection both *in* and *on* practice and offers a unique opportunity to discover discrepancies between *work as imagined* and *work as done*. The debriefings allow the trainees and their trainer to jointly reflect on what went well and what went wrong during the simulator sessions. The reflections do not only draw on what happened during training but also depend on each participant's level of experience and their successes or failures at sea. This demonstrates the importance of debriefing as a learning tool. This aspect of simulator-based training requires more attention from researchers. Future studies may, for example, investigate how to structure and facilitate debriefing sessions to support the needed reflection and sharing of experience among professionals.

The focus on social processes in this thesis has broadened the knowledge about safety leadership in the maritime domain and added to the understanding of how to train maritime officers. New work processes and increased automation in the maritime industry will create new frames of action for team collaboration and leadership. The maritime industry faces a paradigm shift in the coming years where autonomous marine systems and remote-operated vessels are predicted to set new standards for global trade and shipping.¹¹ It is foreseen that much of the work tasks performed on board today may be moved ashore or automated. Remote-operated ships with reduced manning monitored and operated from shore control centres is predicted to be a part of the future. This will challenge the conventional ways of working in the industry and will require new legislations and standards for safety, manning,

¹¹ The ongoing *Yara Birkeland* project is described as a 'game changer' for global maritime transport with respect to both emissions as well as autonomy. <https://www.yara.com/knowledge-grows/game-changer-for-the-environment/>

and leadership training in the coming years. An interesting question is who will have the final responsibility for the safe operations of the ship? Will there still be a master on board, or will this role and the belonging responsibilities be placed with an onshore control room operator? What rank and training will this person need to fulfil the leader role and handle emergency situations? How can trust be established and maintained among crew and shore centre staff?

This thesis has investigated the automated DP system and pointed to two aspects that may be valuable to investigate further. Learning to operate new advanced technological systems will require detailed knowledge of the technological attributes of the system, but an understanding of the physical and functional factors of the equipment alone may not be sufficient, as indicated in the work on simulator fidelity. Future operators must have an overall understanding of the socio-technological system of which they are a part, and training programs must provide a realistic backdrop for practicing leadership and decision making in dispersed teams located at the ship and at different shore control centres. Emphasising social processes along with technical aspects in simulator-based training may prove valuable to meet unforeseen risks in the changes the industry is facing in the coming years.



Photo: Kristian Topp. Copyright Kongsberg Group

Picture 7 Able-bodied seafarer.

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9 APPENDIX

9.1 NOTIFICATION NORWEGIAN CENTRE FOR RESEARCH DATA



Aud Marit Wahl
Institutt for industriell økonomi og teknologiledelse NTNU
Alfred Getzvei 3
7491 TRONDHEIM

Vår dato: 08.06.2016

Vår ref: 48687 / 3 / ASF

Deres dato:

Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 18.05.2016. Meldingen gjelder prosjektet:

48687	<i>Resource Management & Team Leadership: Maintaining Safety In Shipping</i>
<i>Behandlingsansvarlig</i>	<i>NTNU, ved institusjonens øverste leder</i>
<i>Daglig ansvarlig</i>	<i>Aud Marit Wahl</i>

Personvernombudet har vurdert prosjektet og finner at behandlingen av personopplysninger er meldepliktig i henhold til personopplysningsloven § 31. Behandlingen tilfredsstillter kravene i personopplysningsloven.

Personvernombudets vurdering forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, <http://www.nsd.uib.no/personvern/meldeplikt/skjema.html>. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, <http://pvo.nsd.no/prosjekt>.

Personvernombudet vil ved prosjektets avslutning, 31.12.2019, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Kjersti Haugstvedt

Amalie Statland Fantoft

Kontaktperson: Amalie Statland Fantoft tlf: 55 58 36 41

Vedlegg: Prosjektvurdering

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.



I følge meldeskjemaet skal deltakerne i studien informeres muntlig om prosjektet og samtykke til deltakelse. For å tilfredsstille kravet om et informert samtykke etter loven, må utvalget informeres om følgende:

- hvilken institusjon som er ansvarlig
- prosjektets formål
- at opplysningene behandles konfidensielt, og hvem som vil ha tilgang
- at det er frivillig å delta og at man kan trekke seg når som helst uten begrunnelse
- dato for forventet prosjektslutt, og at data anonymiseres ved prosjektslutt
- kontaktopplysninger til forsker.

Dere har opplyst om at dere skal innhente personopplysninger gjennom observasjon. Personvernombudet forutsetter at de som observeres informeres om prosjektet og om hvilke opplysninger som skal registreres. Dersom det skal registreres personopplysninger, må dem det gjelder samtykke til dette.

Personvernombudet legger til grunn at forsker etterfølger NTNU sine interne rutiner for datasikkerhet.

Forventet prosjektslutt er 31.12.2019. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres.

Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:

- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som f.eks. bosted/arbeidssted, alder og kjønn)
- slette digitale lyd-/bilde- og videoopptak

9.2 INTERVIEW GUIDES

General introduction text used prior to interviews:

- ✓ This interview is part of a PhD study where the main topic is maritime leadership.
- ✓ Collecting and storing of data adhere to the guidelines described by the Norwegian Data Protection Official for Research (NSD) and NTNU.
- ✓ The information will be anonymized and only I will have access to the material. The project is finalized 31/12 2019.
- ✓ The interview lasts 15-60 minutes. Your participation is voluntarily, if there are questions, you do not want to answer that is OK. You may withdraw from the interview at any time.
- ✓ In case of audio recording: the recording will be deleted when file is transcribed.
- ✓ Contact information: aud.wahl@ntnu.no

Interviews vessels: General structure			
Rank:	Years at sea:	Age:	Nationality:
Education/ Experience			
<i>At vessel /in company/other companies</i>			
<i>Describe your leadership training (formal /informal)</i>			
Your work tasks			
<i>General description</i>			
<i>Leadership responsibilities/tasks/goals</i>			
What is good leadership at sea?			
<i>How do you want your leader to act?</i>			
<i>How do you as a leader try to act?</i>			
Give examples of poor leadership			
What is the company's expectations to the leaders?			
Leadership in an emergency/crisis compared to daily work			
Questions to clarify/verify observations			
?			
?			
Comments			

Interviews training centers: General structure			
Rank:	Years at sea:	Age:	Nationality:
Education/ Experience			
<i>At vessel /in company/other companies</i>			
Your work tasks			
<i>Leadership responsibilities/tasks/goals</i>			
What is important for good quality simulator-based training?			
<i>Similarities simulator and vessel/ Bridge equipment /software/ Hydrodynamics/visual effects</i>			
What makes training realistic?			
-The exercises			
<i>Daily tasks/incidents Errors/distractions</i>			
-Role of other participants			
<i>Colleagues/crew mates Rank/ senior officers</i>			
-Role of the simulator instructor?			
<i>Background/experience Lecture/facilitate Roleplay</i>			
Debriefing			
<i>Length/where/structure/ Dialogue/feedback</i>			
Questions to clarify/verify observations			
?			
?			
Comments			

9.3 THE PAPERS

The papers are presented in the following order:

Paper 1 (Wahl A. M. and Kongsvik T. 2017)

Fra helt til mellomleder: Hverdagsledelse til sjøs.

Published in *Heldal, Antonsen og Kvalheim (eds.) Sikkerhet og ledelse. Oslo: Gyldendal Akademiske, 171-193.*

Paper 2 (Wahl A. M and Kongsvik T. 2018)

Crew resource management training in the maritime industry: a literature review.

Published in *WMU Journal of Maritime Affairs, 17 (3), 377-396.*

Paper 3 (Wahl A. M. 2019)

Expanding the concept of simulator fidelity: The use of technology and collaborative activities in training maritime officers.

Published in *Cognition, Technology & Work. <https://doi.org/10.1007/s10111-019-00549-4>*

Paper 4 (Wahl A. M., Kongsvik T. and Antonsen S. 2019).

Balancing Safety I and Safety II: Learning to manage performance variability at sea using simulator-based training.

Enclosed version submitted to *Reliability Engineering & System Safety* March 3rd, 2019.

Paper was accepted for publication October 12th. The final version is found at

<https://doi.org/10.1016/j.ress.2019.106698>

KAPITTEL 8

Fra helt til mellomleder: Hverdagsledelse til sjøs

Trond Kongsvik og Aud Marit Wahl

Den maritime historiske litteraturen gir mange eksempler på ulike typer ledere. Kaptein Ernest Shackleton (1874–1922) er en av dem som har blitt beskrevet som en dyktig leder. Han var en av nittenhundredallets eventyrere og mest kjent for å ha ledet en rekke mislykkede polekspedisjoner. I august 1914 la han ut på en ferd til Antarktis med forskningsfartøyet *Endurance*. I januar 1915 frøs fartøyet fast i isen i Weddelhavet. Shackleton og hans menn var fanget om bord i ti måneder mens båten sakte drev nordover med isen. Skroget ga til slutt etter for det voldsomme trykket fra isen, skipet begynte å ta inn vann, og de ble nødt til å evakuere og slå leir på isen. Her sov de i telt i til tider ekstrem kulde. Til tross for en tilværelse under konstant fare og sterkt fysisk ubehag klarte mennene å holde motet og humøret oppe. I april 1916 begynte isen å smelte under dem. Ved hjelp av tre skrøpelige livbåter klarte de å ta seg til land på Elefantøya. Shackleton og fem av mennene forlot de andre her, og ved bruk av den ene livbåten tok de seg frem til en hvalstasjon på Sør-Georgia, hvor de endelig fikk hjelp. I august ble resten av mannskapet reddet. Alle de 28 om bord overlevde den to år lange kampen i isødet (Shackleton, 1917). Shackletons lederstil har i ettertid blitt trukket frem som hovedgrunn til at alle kom seg velberget gjennom den strabasjose ferden (Morrell & Capparell, 2001). Hans evne til å skape et sammensveiset og lojalt lag om bord tidlig i seilasen og deretter opprettholde denne lagånden etter hvert som mannskapet befant seg i en stadig mer alvorlig situasjon, blir av Morrell og Capparell (2001) beskrevet som essensen i god ledelse.

Maritim litteratur gir også eksempler på at dårlig ledelse har bidratt til ulykker. I januar 2012 grunnstøtte cruiseskipet Costa Concordia utenfor kysten av Italia. Francesco Schettino var kaptein om bord. Han fikk i media kallenavnet «Kaptein Feiging» (Skjeggestad, 2013) etter å ha blitt verdenskjent for å ha forlatt det synkende skipet lenge før mange av passasjerene. Hendelsesrapporten (The Italian Ministry of Infrastructure and Transport, 2013) fremhever dårlig ledelse som en hovedårsak til katastrofen. En av årsakene til forliset var at kapteinen valgte å forlate planlagt seilingsrute for å gå nær øya Giglio, angivelig som en gest til en tidligere kollega. Dette prosedyrebruddet førte til at fartøyet etter hvert befant seg farlig nær en dårlig belyst kystlinje på en mørk kveld med høy hastighet og med en fatal svingradius. Resultatet ble en grunnstøting. Det tok 70 minutter fra vannet fosset inn gjennom den 53 meter lange flengen i skroget til den første livbåten ble senket til vannet. Beslutningen om å evakuere de 4229 personene om bord i henhold til eksisterende nødprosedyrer ble ikke tatt av kapteinen, men ble gitt som en direkte ordre fra redningstjenesten på land. Den lange tiden det tok før livreddende tiltak ble iverksatt, kombinert med dårlig kommunikasjon og koordinering av redningsarbeidet om bord, bidro til at mange mistet livet. 32 personer døde denne natten. Schettino ble i 2015 dømt til 16 år i fengsel for uaktsomt drap (Elster, 2015).

Begge disse historiene vier at ledelse og lederstil kan knyttes til sikkerhet. Dette kapitlet belyser hva som kan betraktes som god ledelse i en maritim sammenheng, og diskuterer betydningen av lederstil for å ivareta sikkerheten om bord på et fartøy. Det empiriske grunnlaget for kapitlet er feltstudier på tre tankbåter og intervju om maritim ledelse med 50 besetningsmedlemmer på disse båtene. Med basis i data-materialet beskrives det sjøfolk opplever som god ledelse, deretter brukes funnene til en mer teoretisk drøfting av ulike lederstiler og hvordan lederstilen innvirker på sikkerheten. Det teoretiske utgangspunktet er modellen om transformasjonsledelse, supplert med teorien om høypålitelige organisasjoner («High reliability organizations») og hvordan ledelse implisitt blir synlig i dette perspektivet. Kapitlet avsluttes med å antyde videre forskning knyttet til ledelse og sikkerhet i maritim industri.

Teoretisk rammeverk

En kaptein om bord på et skip er en mellomleder på det operative nivået i et rederi, med hovedansvar for sikker og effektiv drift av det fartøyet han eller hun er om bord på. Dette er ledelse i den «skarpe enden» av en organisasjon (Flin, O'Connor & Chrichton, 2008), hvor de som ledes, er involvert i organisasjonens kjernevirksomhet og eksponeres direkte for farene knyttet til verdiskaping. Operativ ledelse

handler om å kunne håndtere et helt spekter av ulike oppgaver fra normal drift til uforutsette kritiske hendelser (Olsen & Eid, 2015). I denne sammenhengen kan ledelse defineres som en prosess som innebærer å påvirke andre i en gruppe for å oppnå bestemte mål i situasjoner som kjennetegnes av uforutsigbarhet og risiko (Olsen & Eid, 2015).

I dette kapitlet er det ikke rederiet, men skipet som sosial enhet som undersøkes med hensyn til ledelse. I en klassisk artikkel av Aubert og Arner (1959) beskrives den sosiale strukturen på et skip som et 24-timers samfunn med få skiller mellom jobb og fritid. Besetningen lever tett på hverandre i lange perioder, isolert fra egen familie, og arbeidsoppgavene fordeles med utgangspunkt i en tydelig faglig og hierarkisk struktur. Besetningen på et skip kan betraktes som en arbeidsorganisasjon, noe som innebærer at det kan betraktes som et formelt, målrettet sosialt system, opprettet for å produsere varer eller tjenester. I maritim sammenheng er tjenesten som tilbys, å frakte last eller passasjerer fra ett sted til et annet på en trygg og sikker måte. For å yte denne tjenesten har hver og en i mannskapet ulike roller og ansvarsområder, både i normal drift og i beredskapssituasjoner. I tillegg til en formell struktur, som gjerne kan beskrives ved hjelp av organisasjonskart og stillingsbeskrivelser, har arbeidsorganisasjoner også en uformell side, som handler om særegne væremåter, arbeidspraksiser, verdier og holdninger, forhold som gjerne oppsummeres i begrepet *kultur* (Kongsvik, 2013).

Operativ ledelse og sikkerhet i maritime studier

Sikkerhetsforskningsfeltet tar for seg både formelle og uformelle sider ved en organisasjon. Eksempler på dette er studier knyttet til sikkerhetskultur (for eksempel Weick, 1987; Reason, 1997; Antonsen, 2009) og styringssystemer (for eksempel Hale, 2003; Kjellén & Albrechtsen, 2017). Mye av den tilgjengelige litteraturen innenfor dette fagfeltet kan derfor sies å beskrive rammebetingelsene for ledelse i den skarpe enden av organisasjoner. Dette gjelder også studier knyttet til maritim sektor. Oltedal (2011) har forsket på sikkerhetskultur og sikkerhetsstyring i norsk kontrollert shippingindustri. Hun identifiserer blant annet bemanningsstrategi, ledertrening og administrativ støtte som sentrale faktorer for å ivareta sikkerhetsnivået i et rederi. Håvold (2010) har sett på måling av sikkerhetskultur på norskeide tankbåter og viser hvordan indikatorer kan være et nyttig ledelsesverktøy for å forebygge ulykker. Størkersen, Antonsen og Kongsvik (2016) viser at sikkerhetsstyringssystemer er effektive verktøy for å forebygge personskader såfremt mannskapet har tilstrekkelig med tid og ressurser, og når prosedyrene samsvarer med personlige, faglige verdier

hos den enkelte. De argumenterer for at effekten er svakere for hendelser med større skadepotensial, for eksempel ved grunnstøting, og at det til og med kan være en negativ sammenheng mellom rigid bruk av prosedyrer i form av økt byråkratisering og gjennomføring av sikkerhetskritiske oppgaver.

Det har tradisjonelt vært lagt mindre eksplisitt vekt på operativ maritim ledelse som fenomen, med unntak av studier knyttet til militære operasjoner. Ett eksempel er Bachman (1988) som har studert offiserer i den amerikanske marinen. Han konkluderte med at de beste lederne er autoritære, men lydhøre for innspill fra andre, er sosialt engasjert og viser interesse og omsorg for sine underordnede. Dette er ledere som er opptatt av å bygge laget gjennom å være synlige rollemodeller med høye krav til seg selv og andre, og som konsekvent straffer dem som avviker fra ønsket standard. Offiserene med disse kjennetegnene var også de som håndterte kritiske kampsituasjoner best.

Det kan synes å være en økende interesse for operativ ledelse også innenfor sivil maritim virksomhet, noe som er i tråd med at det gjøres stadig mer forskning knyttet til operativ ledelse og sikkerhet generelt (se for eksempel Clarke, 2012; Conchie, 2013; Heldal & Antonsen, 2014; Glendon & Clarke, 2015). Borgersen, Hustad, Larsson og Eid (2013) viser i sin studie en positiv sammenheng mellom autentisk lederstil og opplevd sikkerhetsklime. At en kaptein forplikter seg til sikkerhetsarbeidet om bord og fremstår som en positiv rollemodell, blir beskrevet som viktige lederegenskaper. Sandhåland, Oltedal, Hystad og Eid (2017) har sett nærmere på hvordan aktiv og passiv lederstil sammen med psykologiske jobbkrav og situasjonsforståelse påvirker viljen til å ta risiko hos besetningsmedlemmer på dekk og i maskinrommet. De sier at en autentisk (aktiv) lederstil gir bedre situasjonsforståelse og har en positiv effekt på viljen til å ta risiko. Lederens evne til å være oppmerksom på individuelle behov hos besetningen blir brukt som en forklarende faktor. En passiv lederstil (*laissez-faire*) blir beskrevet som dysfunksjonell når det kommer til å ivareta sikkerhet, blant annet i Øyvind Dahls kapittel i denne boken. Wahl og Kongsvik (2017) har undersøkt hva som oppfattes som god ledelse hos sjøfolk. Faglig kompetanse, tydelig autoritet og omsorg for mannskapet er sentrale faktorer. Med utgangspunkt i dette arbeidet foreslår de en klassifisering eller taksonomi for ikke-tekniske ferdigheter som bør vektlegges ved opplæring av maritime offiserer. Ikke-tekniske ferdigheter forstås her som kognitive, sosiale og personlige egenskaper hos en person som komplementerer tekniske ferdigheter, og som bidrar til sikker og effektiv arbeidsutførelse (se også Flin, Connor & Crichton, 2008). Den foreslåtte taksonomien bygger på tilsvarende verktøy i luftfart og beskriver blant annet faktorer som tilstrekkelig grad av autoritet, tydelig kommunikasjon og beslutningstaking.

Disse studiene viser at ledelse og lederstil kan knyttes til sikkerhet. Ved hjelp av transformasjonsledelsesmodellen og teorien om høypålitelige organisasjoner ser dette kapitlet nærmere på denne sammenhengen.

Transformasjonsledelsesmodellen

Lederteori har vært og er et felt i stadig endring. Forskningen på begynnelsen av 1900-tallet fokuserte på personlige egenskaper som en forutsetning for å bli en dyktig leder. På slutten av 1940-tallet ble forskerne mer opptatt av lederstil; hva lederne gjorde, og hva som kjennetegnet deres atferd. På 1980-tallet kom det som har blitt beskrevet som «det nye ledelsesparadigmet» (Bass & Bass, 2008) og de første arbeidene knyttet til transformasjonsledelse fra forskningsmiljøet rundt Bernard M. Bass. Her vektlegges det at ledere tar hensyn til sine underordnedes behov og motiverer dem, og at de fremstår som positive rollemodeller (Bass, 1985). I 1994 la Bass og Avolio frem sin fullspektrumsmodell for ledelse. Dette perspektivet har siden vært hyppig brukt innen forskningsfeltet, også innen sikkerhetsforskning. Clarke (2012) og Glendon & Clarke (2016) gir en oversikt over ulike studier fra dette fagområdet. Modellen har blitt benyttet i studier blant annet innenfor helse-sektoren, olje- og gassindustrien og ulike produksjonsindustrier. Det har derimot vært gjort færre studier knyttet til maritim industri. I dette kapitlet har vi derfor valgt å bruke dette perspektivet som et teoretisk og analytisk rammeverk for å se nærmere på kapteinsrollen. Nøkkelbegreper fra teorien vil bli satt i sammenheng med maritim ledelse.

Teorien om transformasjonsledelse beskriver tre ulike hovedformer for ledelse (Bass & Riggio, 2006): *transformativ*, *transaksjonell* og *passiv ledelse*. Passiv eller «la det skure»-ledelse (Glasø & Thompson, 2013) er egentlig en form for ikke-ledelse som eksempelvis vil komme til uttrykk ved at en kaptein unngår å engasjere seg i arbeidet og er vanskelig tilgjengelig for besetningen. Han eller hun tar (helst) ikke standpunkt i viktige saker, venter i det lengste før avvik eller kritiske situasjoner håndteres, og tar beslutninger motvillig eller ikke i det hele tatt. Denne lederen vil ha en negativ effekt på sikkerheten om bord.

En transaksjonell lederstil kjennetegnes av at en leder vektlegger etterlevelse av regelverk og prosedyrer (Bass & Riggio, 2006). En kaptein vil sette opp klare mål og stille tydelig krav til hva som forventes av mannskapet. *Betinget belønning* brukes for å oppmuntre til trygg og effektiv arbeidspraksis om bord og skjer i form av ros og skryt, eventuelt materielle goder betinget av det den enkelte gjør. *Aktiv avviksstyring* foregår ved at kapteinen følger nøye med på praksis om bord og er oppmerksom på

svakheter eller mangler ved sikkerhetsstyringssystemet. Han eller hun iverksetter tiltak og korrigerer avvik eller feilhandlinger før alvorlige prosedyrebrudd oppstår. *Passiv avviksstyring* synliggjøres gjennom at kapteinen ikke holder seg oppdatert på arbeidet som foregår og venter passivt på at avvik eller feil skal oppstå. Han eller hun griper ikke inn før noen klager, eller prosedyrebrudd og/eller problemene har blitt alvorlige og må tas hånd om.

En transformativ lederstil skapes og beskrives ved hjelp av fire ulike komponenter (Bass & Riggio, 2006). *Idealisert innflytelse* oppnås ved at kapteinen er en tydelig rollemodell i sikkerhetsarbeidet og vektlegger en kollektiv målforståelse hos besetningen. Han eller hun vurderer moralske og etiske konsekvenser av sine beslutninger, og gruppens beste går foran egeninteresse. Kapteinen har stor tillit og respekt hos sine folk. *Inspirerende motivasjon* oppstår gjennom entusiasme og optimisme om bord. Kapteinen skaper en lagånd og inspirer ved å sette høye krav. Han eller hun kommuniserer målene tydelig. *Intellektuell stimulering* foregår ved at kapteinen oppmuntrer besetningen til å kontinuerlig vurdere eksisterende praksis og etablerte sannheter med vekt på å redusere risiko. Alle oppfordres til å komme med forslag som kan gjøre jobben mer sikker og effektiv. Enkelt personer kritiseres ikke offentlig. *Individuell støtte* skjer ved at kapteinen delegerer arbeidsoppgaver og gir underordnede nye utfordringer slik at de kan oppleve personlig vekst og videreutvikle sine sterke sider. Han eller hun bruker tid på å lytte til individuelle behov, gir støtte, råd og bruker tid å lære opp sine folk.

Høypålitelige organisasjoner

Organisatoriske faktorerets betydning for sikkerhet fikk aktualitet på slutten av 1980-tallet. En viktig bakgrunn for dette var granskninger etter flere storulykker, både i maritim sektor og innen kjernekraft og prosessindustri. Disse granskningene identifiserte forhold som ledelse, kommunikasjon og kompetanse som sentrale årsaker til ulykkene (Hale & Hovden, 1998).

Den økte interessen for organisatoriske forhold førte til at nye teoretiske perspektiver ble utviklet. Et av de mest kjente er teorien om høypålitelige organisasjoner – eller «High reliability organizations» – HRO-er (Weick, 1987; LaPorte & Consolini, 1991; Weick, Sutcliffe & Obstfeld, 1999; Weick & Sutcliffe, 2007; Rosness, 2010). Utgangspunktet var en observasjon om at noen virksomheter så ut til å unngå større ulykker, til tross for at man opererte under komplekse forhold både teknologisk og organisatorisk. Dette gjaldt blant annet militære hangarskip, akuttmottak på sykehus

og flykontrollsenters. Et sentralt anliggende ble å identifisere hvilke organisatoriske egenskaper som lå til grunn for at man klarte å ivareta sikkerheten selv om kompleksiteten var stor. Særlig tre egenskaper er fremhevet:

- 1 *Organisatorisk redundans* innebærer at en organisasjon er bemannet slik at flere kan fange opp feil som oppstår, gjennom overlappende ansvarsområder og kompetanse. På en båt kan dette blant annet handle om rollene kaptein/overstyrmann og maskinsjef/førstemaskinist.
- 2 HRO-er kjennetegnes også av fleksibilitet og *evnen til å omstille seg spontant* når omstendighetene krevde det. I potensielt farlige avvikssituasjoner blir fagekspertise verdsatt og formell rang uviktig. De med realkompetanse og praktisk erfaring gis handlingsrom til å løse problemet og ta beslutninger. I praksis vil dette ofte innebære at beslutninger blir tatt av dem som er nærmest farene, det vil si de i «den skarpe enden».
- 3 HRO-er kjennetegnes ifølge perspektivet også av *mindfulness*, et begrep som på norsk løst kan oversettes til «oppmerksom tilstedeværelse». Weick og Sutcliffe (2007) fremhever at dette innebærer høy oppmerksomhet på alle typer avvik fra normalsituasjonen, også de mindre, og evnen til å vurdere om de kan ha bakgrunn i svakheter i systemet. Man motstår forenklinger og søker nyanseerte forklaringer på avvik som oppstår. Det operasjonelle og det som faktisk skjer i «den skarpe enden», blir dermed betraktet som mest sentralt. Evnen til å gjenopprette en normaltilstand og fortsette en operasjon selv om noe uforutsett og potensielt farefullt skjer, er et sentralt kjennetegn ved HRO-er.

Ledelse er i liten grad eksplisitt tatt opp i HRO-perspektivet. Det ligger likevel implisitt i de egenskapene som fremheves. Organisatorisk redundans innebærer mer enn et strukturelt overlapp, det vil si at man har «flere par øyne». Redundans i denne sammenhengen har også en kulturell dimensjon (Rosness et al. 2010), som innebærer at det er takhøyde for å faktisk etterprøve beslutninger som andre eller en selv gjør. Implisitt innebærer dette i vår sammenheng kapteiner som tar innvendinger på alvor, som er åpen for innspill også når det gjelder egne handlinger, og som kan skape et samarbeidsklima hvor det forventes at man sier ifra. Evnen til å omstille seg spontant vil også kreve kapteiner som er villige til – og faktisk kan – delegerer og la folk med realkompetanse slippe til. Videre vil kapteiners lederstil også kunne ha betydning for hvor «mindful» en virksomhet blir i stand til å være. «Mindfulness» innebærer altså åpenhet for kritikk, å ta innspill på alvor og se verdien av kompetansen hos hver enkelt person i mannskapet.

Metode

Dette kapitlet er basert på et doktorgradsprosjekt om ledelse til sjøs. Det empiriske materialet er hentet fra feltarbeid hos et rederi.

Casebeskrivelse

Rederiet er en global organisasjon, lokalisert i 14 ulike land. Det består av ca. 7000 ansatte og har flere ulike flåter med til sammen mer enn 200 fartøy. Virksomhetsområdet er i all hovedsak lagring, produksjon og transport av olje og gass.

Data i dette kapitlet er hentet fra feltstudier om bord på tre ulike tankbåter i selskapet. To av skipene tilhørte offshoreflåten i rederiet og var bøyelastere. Det vil si at de brukes til å laste olje fra anlegg i havet. Disse gikk i Nordsjøen på oppdrag for ulike oljeselskap på henholdsvis norsk og britisk sektor. Det tredje fartøyet tilhørte den konvensjonelle tankflåten i selskapet og var på oppdrag i Sør-Kina-havet.

Arbeidet om bord er hierarkisk organisert ut fra profesjonstilhørighet, med en avdelingsvis inndeling: bro, maskin og forpleining. Se figur 8.1. Arbeidet på dekk organiseres av brooffiserene og er derfor plassert under denne avdelingen til tross for at arbeidsoppgavene er veldig forskjellige fra dem som utføres på broen til et skip. Internasjonale bestemmelser (International Maritime Organization, 2011) gir føringer for roller og ansvarsområder. Kapteinen er den med høyest rang om bord og har ansvaret for sikker og effektiv drift av skipet. Overstyrmannen er kapteinenes nestkommanderende og vil overta kommandoen over skipet om kapteinen ikke lenger kan utføre jobben. Begge rollene krever navigatørsertifikat. Maskinsjefen er ansvarlig for mekanisk fremdrift samt drift og vedlikehold av mekaniske og elektriske installasjoner på fartøyet. Førstemaskinisten er maskinsjefens nestkommanderende. Maskinistsertifikat er et krav for å inneha stillingene. Disse lederne kalles «topp fire» og utgjør ledergruppen om bord. Båtsmann er arbeidsleder for mannskapet på dekk og rapporterer som regel til overstyrmann.

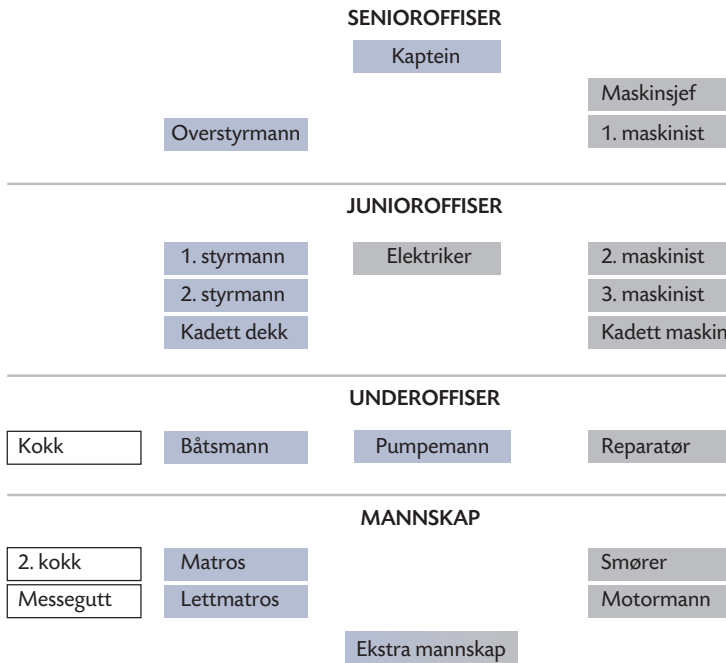
Antallet personer om bord er avhengig av arbeidsoppgavene. På disse tre skipene var det henholdsvis 23, 26 og 27 personer. Av disse var bare én kvinne. Besetningen på alle fartøyene var en sammensetning av ulike nasjonaliteter. Filippinere utgjorde majoriteten på alle tre skipene, fra junioroffiserer og nedover i rang. Den konvensjonelle tankbåten hadde mange indere om bord, fra senioroffiserer og nedover. Kapteinen var søreuropeisk. Bøyelasterne hadde begge norsk kaptein. På den ene var majoriteten av offiserene norske, på den andre var flest fra Polen. I tillegg var det enkeltpersoner fra Russland, Kina og Latvia i mannskapet.

Antall måneder den enkelte er om bord i ett strekk, varierer med rang, nasjonalitet og flåtetilhørighet. Kortest tid om bord er europeiske offiserer i Nordsjøen, som har et system med fire uker på jobb og fire uker fri. Filippinsk mannskap på den konvensjonelle tankbåten var om bord opptil ti måneder sammenhengende, med to måneder fri. Senioroffiserene er alle fast ansatt i rederiet og jobber som regel på samme båt i flere år. Junior- og underoffiserer mønstrer på samme båt som forrige tur så langt det er mulig ut fra turnus. Dette gjelder også for mannskapet for øvrig, men mange har ikke fast kontrakt med rederiet, og arbeidssted vil være avhengig av om de får fornyet arbeidsavtale.

Topp fire om bord prioriterer og koordinerer arbeidsoppgaver og ressursbruk innfor gitte rammer. Arbeidet styres i henhold til internasjonalt og nasjonalt lovverk, for eksempel preventivt vedlikehold av teknisk utstyr, testing av sikkerhetskritisk utstyr og etterlevelse av arbeidstidsordningen. Kundene, her oljeselskapene, påvirker seilingsplanen og når og hvor det skal lastes og losses. Havnemyndigheter, oljeterminaler, loser og taubåter er eksempler på andre aktører som påvirker seilingsplanen. I tillegg er været en faktor som til enhver tid påvirker planleggingen og fører til endringer underveis. Rederiet legger selvfølgelig også føringer, for eksempel i form av styringssystem, årlige budsjettkrav og tilgjengelig arbeidskraft i form av antall hender om bord.

Datainnsamling

Observasjoner av det daglige arbeidet om bord og uformelle samtaler med folk underveis utgjør hovedtyngden av datamaterialet. Feltarbeidene var på henholdsvis åtte, tretten og tolv dager og ble gjennomført i andre halvdel av 2016. Det ble utført formelle intervjuer med 50 personer. Hensikten med intervjuene var primært å supplere observasjonsdata og var en anledning til å få mer detaljerte forklaringer. I tillegg ble informantene bedt om å reflektere over god og dårlig lederatferd. Intervjuene med senioroffiseren om bord var mer detaljert og varte lenger (45–60 minutter) enn med resten av mannskapet (15–30 minutter). Ni ble av intervjuene gjort på norsk, resten på engelsk. Engelsk var ikke morsmålet til noen av de intervjuede, og i flere av intervjuene var derfor språk en utfordring. Data inkluderer ulike rederispesifikke dokumenter, blant annet hendelsesrapporter, prosedyrer og stillingsbeskrivelser.



Figur 8.1 Organisering om bord på en tankbåt. Figuren viser de ulike rollene om bord inndelt i ulike avdelinger: Bro og dekk er markert i blått, maskin er markert i mørk grå og forpleining er markert i lys grå.

Hva anses som god ledelse til sjøs?

En sentral del av samtalen med besetningen om bord handlet om hva man oppfattet som god ledelse i det daglige arbeidet, både i form av egenskaper og arbeidspraksis. Forhold og dimensjoner som ble ansett som sentrale, illustreres med sitater og kommenteres nedenfor.

Den harmoniske familien som ideal

Denne båten er vårt andre hjem. Du bør oppføre deg som om du ville ha gjort mot familien din. (Underoffiser)

Flere beskriver livet om bord som sitt andre hjem. Omsorg og toleranse for andre er derfor like viktig her som i en familie. Dette er selve grunnmuren i hvordan besetningen omgås og forholder seg til hverandre, både i arbeidssituasjoner og på fritiden. En god leder er derfor en som engasjerer seg i dem han jobber sammen

med, som ikke bare snakker om arbeidsoppgavene som skal utføres, men som også følger opp enkeltpersonene og viser at han bryr seg om alle om bord. Ord som «far» og «den gamle» blir brukt om kapteinen og indikerer hvordan han blir sett som overhodet i familien om bord. I tråd med dette bildet er *omsorg* det ordet flest nevner når de blir bedt å si hva god ledelse er.

Å være høflig og behandle hverandre med respekt fremheves som viktig for arbeidsmiljøet om bord. Uttrykket «harmonisk båt» brukes av mange for å beskrive et positivt arbeidsmiljø. Harmoni blir også fremhevet som viktig for å ivareta sikkerheten. En junioroffiser uttrykte dette på denne måten: «Hvis det ikke er harmoni om bord, vil ulykkene komme.» Flere nevner at god ledelse handler om å opprettholde god harmoni, og at lederstilen til senioroffiserene setter standarden for hvordan alle omgås. En kaptein som styrer med jernhånd og har en kommanderende stil, som snakker unødvendig høyt eller roper og kjefter på sine folk, vil ha en sterk negativ effekt på arbeidsmiljøet, og dermed også sikkerheten, ved at underordnede ikke tør å si ifra om noe er galt.

De fleste sier at det er lite konflikter om bord, det er mer uenigheter. Når man jobber så tett på hverandre, prøver de fleste å holde litt igjen og prøver å unngå diskusjoner og tema som kan skape grunnlag for konflikter. Mange påpeker at det ofte er færre konflikter om bord på båter med flere ulike nasjonaliteter. De mener grunnen til dette er at alle er oppmerksomme på kulturelle ulikheter og prøver å unngå samtaleemner som kan skape grobunn for konflikter som religion, politikk og familieforhold. En senioroffiser sa: «Det er viktig å forstå at vi er fra ulike kulturer, og at alle er langt unna familien sin.»

Samtidig beskrives det også noen negative sider ved å vektlegge harmoniidealet. Flere av senioroffiserene forteller at de kvier seg for å gi negative tilbakemeldinger når underordnede har gjort en dårlig jobb, for eksempel under medarbeidersamtaler. De er bekymret for at det skal oppstå en misnøye som kan forsure arbeidsmiljøet og gå utover samarbeidet i laget og dermed sikkerheten. Denne tilbakeholdenheten med å si ifra ser ikke ut til å gjelde for tydelige avvik fra prosedyrer eller farlig atferd. En av grunnen til dette er at det oppfattes som omsorg å si ifra. En underoffiser uttrykker dette med å si at «en god leder passer på at alle er trygge». Alle ønsker å komme hjem uskadd og med helsen i behold. Atferd som kan utsette enkeltpersoner eller hele laget for fare, forventes det at ledere tar tak i og korrigerer umiddelbart. Det ligger også en tydelig forventning og tillit fra de underordnede om at senioroffiserene, og kapteinene spesielt, til enhver tid prioriterer sikkerheten for mannskapet over produksjonskrav.

Lagarbeid og delegering

Lagarbeid er viktig. Jeg forsøker å dele ansvaret med de andre, selv om det til slutt hviler på mine skuldre. Lytte til alle. Snakke med hverandre. Hvis jeg er usikker på hvordan en jobb bør gjøres, så diskuterer vi. Jeg får alle til å presentere sine ideer, og så tar vi den som vil fungere best, uavhengig av rang til den som kom med forslaget. (Senioroffiser)

I et så lite samfunn som det som utgjør besetningen på en båt, blir det oppfattet som spesielt betydningsfullt at alle tar ansvar og bidrar aktivt i arbeidet. Det er til tider høy arbeidsbelastning, og det er et begrenset antall hender til å gjøre jobben. Det krever derfor godt samarbeid i og mellom de ulike arbeidslagene for å kunne utføre jobben trygt og effektivt. Derfor sier de fleste at *god ledelse handler om lagarbeid*.

Mange av informantene fremhever betydningen av at en leder lytter til folkene sine. Det å ha en god dialog og være åpen for andre meninger blir ansett som essensielt. Samtidig er det nødvendig at lederen gir klare, gode beskjeder. Jo mer kritisk jobben er, desto viktigere blir dette.

At lederen er støttende og lar andre slippe til og prøve seg på nye arbeidsoppgaver, blir vektlagt av de fleste. En junioroffiser sier: «En god leder er inkluderende, han ser potensialet i enkeltpersoner, tør å gi fra seg ansvar og lar andre ta ansvar. Han kan gi de underordnede utfordringer slik at de ikke går i samme tralten. Det kan fungere som forberedelse til neste stilling.» Spesielt førstestemaskinistene, overstyrmennene og junioroffiserene er opptatt av å få faglige utfordringer og på den måten lære mer. De ser dette som en god mulighet til å forberede seg på opprykk i rang og fremtidig ansvar.

Opplæring av mannskap med lavere rang blir beskrevet som en viktig del av en leders oppgaver om bord. Å sørge for at overstyrmannen har nødvendig kompetanse til å kunne overta om kapteinen faller fra, er nødvendig for å opprettholde sikker drift av båten. Det er også en forventning om at kapteinen skal opprettholde sin kompetanse slik at han kan utføre arbeidsoppgavene til de andre navigatørene om bord. Dette fokuset på å skape en redundans i organisasjonsstrukturen påvirker alle nivå i hierarkiet og måten arbeidet organiseres på. Å ha god overlappende faglig kunnskap i hele laget blir ansett som en avgjørende faktor for å ivareta sikkerheten.

Fagkompetanse og synlig ledelse

Jeg skulle gjerne hatt mer tid til å være involvert i praktisk arbeid. Hvis de ikke ser deg på dekk, blir ikke jobben gjort ordentlig. (Senioroffiser)

Det vektlegges at kapteinen bør ha god teknisk forståelse av jobben som gjøres om bord. Dette skyldes ikke bare behovet for å bygge strukturell redundans som beskrevet ovenfor. Faglig kunnskap er nødvendig for å kunne veilede besetningen i god arbeidspraksis. God forståelse av systemene om bord er avgjørende for å avdekke om måten arbeidet utføres på, medfører en risiko samt behovet for eventuelle sikkerhetstiltak. Faglig kunnskap kombinert med erfaring skaper grunnlaget for en årvåkenhet knyttet til avvik i daglig drift som kan bidra til at tekniske feil eller svikt i systemer oppdages før de eskalerer og fører til alvorlige situasjoner.

Å aktivt delta i arbeidet om bord gjør det også enklere for en leder å overvåke og kontrollere aktivitetene om bord. Dette handler også om muligheten til å bli oppfattet som en lett tilgjengelig leder for mannskapet. Det blir sett på som enklere å henvende seg til en med høyere rang i en jobbsituasjon enn å oppsøke vedkommende på kontoret. Av sikkerhetsmessige hensyn er det viktig at terskelen for å henvende seg til kapteinen er lav, for eksempel om man er usikker på hvordan jobben skal utføres. Lederens funksjon som rollemodell blir også fremhevet. Lederens synlige atferd om bord, for eksempel i form av etterlevelse av sikkerhetsprosedyrer og bruk av personlig verneutstyr, legger sterke føringer for hvordan resten av mannskapet velger å utføre arbeidet. Samtidig uttrykker senioroffiserene frustrasjon over at jo høyere på rangstigen de kommer, desto mindre mulighet får de til å ta direkte del i et praktiske arbeidet om bord. Administrative oppgaver som bestillingsrutiner, vedlikeholdsplanlegging, ressursstyring og koordinering av arbeid tar mye av deres tid.

Autoritet og kameratskap

Det er ikke bra å bli for mye venn, kompisjefen som ikke våger å si ifra eller ta en beslutning. Det skal være autoritet – konkret, tydelig, men allikevel rom for diskusjon. (Junioroffiser)

Rang er tydelig beskrevet i organisasjonskartet. Det viser hvem som er ledere om bord, og hvem som har formell autoritet. Den tydelige hierarkiske inndelingen gjør at det er liten tvil om arbeidsoppgaver, ansvar og hvem som tar endelige beslutninger. Likevel blir det å vise tilstrekkelig autoritet ofte uttrykt som en krevende balanse. Det handler blant annet om å kunne tilpasse lederstilen til situasjonen og folkene rundt seg. I en kritisk situasjon forventes det en tydelig, litt autoritær kaptein som tør å ta beslutninger, men som bruker laget som en ressurs hvis situasjonen tillater det. I hverdagen er det ønskelig med en leder som lar andre slippe til, og som inviterer til dialog, men som ikke fremstår som usikker eller uvitende.

Flere sier at kapteinen må balansere flere ulike roller. Det snakkes om at han er lege og prest, politi og dommer, navigatør og mentor. I uttrykket «politi og dommer» ligger det en forventning om at han aktivt korrigerer prosedyrebrudd og stiller tydelige krav til besetningen. Det forventes at han gir rettferdige tilbakemeldinger ved å belønne arbeidspraksis som ivaretar sikkerheten, og straffer risikofylt atferd eller holdninger i laget.

Samtidig forventes det at en kaptein passer på mannskapet sitt og er «lege og prest» ved behov. Det er viktig å kunne si ifra om problemer på hjemmebane, for eksempel sykdom, dødsfall eller samlivsbrudd, som kan ta fokus vekk fra jobben om bord og på den måten påvirke sikkerheten. Også forhold ved fysisk helse som kan påvirke den enkeltes arbeidsevne, er det viktig å få tatt tak i, enten det gjelder tannpine eller vond rygg. Det er et uttrykt ønske fra dem med høyest rang at de får kjennskap til og muligheten til å hjelpe ved denne typen problemer. I praksis viser det seg ikke alltid å fungere slik, mye på grunn av avstanden mellom roller i det formelle hierarkiet om bord.

Det å være navigatør betyr å opprettholde faglig kompetanse som beskrevet ovenfor. Å være en mentor gjennom å aktivt dele denne kunnskapen, enten ved å delegere arbeidsoppgaver eller veilede dem med lavere rang, blir oppfattet som viktig for å bygge en organisasjon med nødvendig grad av redundans.

Hverdagsledelse som grunnlag for håndtering av kritiske situasjoner

Å vite at alle kan jobben sin i hverdagen, det legger grunnlaget for hvordan det jobbes i en krise. Må kunne bruke folka rundt seg, må stole på folk om bord. (Senioroffiser)

De færreste har opplevd alvorlige hendelser eller ulykker i løpet av sine år på sjøen. Når de blir spurt om sine forventninger til god ledelse i en krisesituasjon, trekkes det frem mange av de samme egenskapene som blir beskrevet for hverdagslederen. Det å være tilstrekkelig autoritær blir trukket frem som spesielt viktig. Mange i mannskapet forventer at kapteinen viser omsorg for mannskapet i en nødssituasjon og gjør valg som ivaretar sikkerheten til alle om bord på en best mulig måte. Gjensidig tillit blir beskrevet som en viktig faktor. I en kritisk situasjon bør kapteinen ha tillit til at alle om bord vet og gjør det som er deres ansvar. Denne tilliten bygges i hverdagen. Det fremheves at en leder må bli kjent med de sterke og svake sidene ved teamet om bord og seg selv gjennom det daglige arbeidet. Senioroffiserene påpeker viktigheten av å la flest mulig prøve seg på nye arbeidsoppgaver, både for å bli bedre kjent, men også for å bygge kunnskap. Ved å la dem med lavere rang

slippe til på broen eller i maskinrommet er det flere som kan ha mulighet til å hjelpe til i en kritisk situasjon. Mannskapet legger også vekt på at de må kunne stole på sine offiserer. De forventer en kaptein med god faglig kompetanse som evner å ta tøffe valg og gjøre viktige beslutninger. For at de skal stole på at han vil gjøre alt i sin makt for å berge livet til sine menn i en nødssituasjon, må han vise omsorg for den enkelte også i hverdagen.

Drøfting

Med basis i datamaterialet drøftes i denne delen sjøfolkenes beskrivelser av god ledelse. Deretter brukes funnene til en mer teoretisk diskusjon av ulike lederstiler og hvordan lederstil kan innvirke på sikkerheten.

God ledelse til sjøs

Mannskapet gir uttrykk for et relativt enhetlig syn for hva god ledelse i det daglige arbeidet innebærer til sjøs. Som familiens overhode stimulerer en god kaptein til et harmonisk arbeidsmiljø og viser respekt og omsorg for andre. Han bygger teamet gjennom å vise tillit, delegerer arbeid og lytte til sine folk. Hans fagkompetanse og kunnskap om arbeidet om bord er grunnlaget for å bygge en redundant organisasjonsstruktur. Synlig ledelse ved å delta aktivt i arbeidet som gjøres er viktig og bidrar til å skape autoritet.

Dette er elementer man finner igjen i en transformativ lederstil. I analysen finner vi ulike komponenter som i teorien konstituerer transformasjonsledelse (Bass & Riggio, 2006). Kapteinen som rollemodell og «pater familias» er eksempel på *idealisert innflytelse*. Vektleggingen av en leder som skaper lagånd og stiller høye krav til sikkerhet, peker på *inspirerende motivasjon*. Elementer som å etterspørre informasjon og være åpen for forslag til mer sikker og effektiv drift viser et ønske om en leder som legger til rette for *intellektuell stimulering*. Beskrivelsene av en god kaptein som en leder som delegerer oppgaver, viser omsorg og bruker tid på opplæring, er eksempler på *individuell støtte*.

Det er imidlertid også noen oppfatninger om god ledelse som harmonerer med en transaksjonell lederstil. At kapteinen er med i daglig drift og er årvåken for mulige feil og retter dem, er sammenlignbart med *aktiv avviksstyring*. Dette kan knyttes til de sikkerhetsstyringssystemene kapteinen har som verktøy. Sikkerhetsstyring innebærer et generelt mål om aktiv avviksstyring, basert på kvalitetstenkning og kontinuerlig forbedringstankegang. Videre er en konsekvens av idealet om harmoni

at besetningen søker å unngå tema som kan medføre mer åpne konflikter. I et tett arbeidsfellesskap med personer fra ulike kulturer og hvor man er kontinuerlig sammen over lang tid, anses konflikter som potensielt skadelig for arbeidsmiljøet. Behovet for harmoni forsterkes ved at skipet utgjør et 24-timers samfunn (Aubert & Arner, 1959) hvor besetningen er fysisk isolert fra venner og familie i lange perioder. Harmoniidealet kan bidra til at kapteinen begrenser negative tilbakemeldinger, for eksempel om at arbeidsoppgaver ikke utføres godt nok. Dette impliserer en lederstil hvor avviksstyringen også kan være *passiv*, det vil si at kapteinen ikke intervensjonerer før det er helt nødvendig, og hvor negative forhold har fått utviklet seg over lengre tid. Selv om en mer passiv lederstil er forståelig ut fra konteksten en besetning befinner seg i, er det lett å se for seg at det ha en negativ innvirkning på sikkerheten om bord. Hvis passiv avviksstyring blir for dominerende, er det en fare for at det kan oppfattes som manglende ledelse eller «la det skure»-ledelse (Bass & Riggio, 2006; Glasø & Thompson, 2013). Resultatet kan bli at avvik fra god og trygg arbeidspraksis normaliseres, og man står i fare for at dette ikke blir korrigert før en ulykke oppstår.

Transformasjonsledelsesmodellen (Bass & Riggio, 2006) kan betraktes som normativ, hvor den transformativ leder er idealet. En slik lederstil harmonerer godt med demokratiske idealer om medbestemmelse, og er ansett som sentral for ledelse av organisatoriske endringsprosesser (Denhardt & Campell, 2006). Mer grunnleggende betraktes også en transformativ lederstil som et grunnlag for moralsk utvikling både blant ledere og de som ledes (Burns, 1978). Når det gjelder sikkerhet, indikerer imidlertid intervjumaterialet at noen sider ved en transaksjonell lederstil også har positive effekter. Aktiv avviksstyring kan ses som et grunnleggende element i å ivareta sikkerheten i en organisasjon som opererer i en høyrisikokontekst. Etterlevelse av regler og tydelige konsekvenser ved brudd på reglene er nødvendig for å ivareta sikkerheten (Dahl, 2014). Det oppleves også som omsorg å korrigere avvikende atferd gjennom rettferdige tilbakemeldinger til enkeltpersoner eller hele gruppen. Med andre ord kan skillet mellom lederstiler være mer flytende i praksis enn i teorien.

Andre studier tyder også på at fleksibel bruk av både transformativ og transaksjonell lederstil er fordelaktig for sikkerheten på en arbeidsplass. Clarke (2012) viser i sin studie at en aktiv, transaksjonell lederstil har positiv innvirkning på sikkerhetsklima og medarbeideres etterlevelse av regler og prosedyrer. Hun viser videre at transformativ ledelse er viktig for å oppmuntre til aktiv deltakelse i sikkerhetsarbeidet blant de ansatte. De to lederstilene trenger med andre ord ikke være

gjensidig utelukkende. Glasø og Thompson (2016) sier at transaksjonell ledelse kan være effektiv i byråkratiske styringssystem med rutinepreget, veldefinerte og standardiserte arbeidsoppgaver, og hvor en spesialisert arbeidsstokk kjennetegner organisasjonen. Hverdagen på et handelsfartøy passer godt til denne beskrivelsen. Samtidig er arbeidet tidvis komplekst og gjennomføres i omgivelser preget av stor uforutsigbarhet, hvor kontinuerlig forbedring er avgjørende for sikker drift. Dette krever bruk av transformasjonsledelse.

Sett fra en maritim leders ståsted vil en god håndtering av en *kritisk* situasjon på den ene siden kreve at mannskapet følger fastsatte beredskapsprosedyrer og etterlevelse av det man har trent på. I en slik situasjon vil kapteinens rolle være å overvåke at dette skjer, og å gi korreksjoner dersom det er nødvendig. Med andre ord vil en transaksjonell lederstil kunne være formålstjenlig for å kunne ivareta sikkerheten. På den andre siden vil også improvisasjon fra mannskapet ofte være nødvendig, fordi prosedyrer aldri vil være fullt ut dekkende for alle kritiske situasjoner som kan oppstå. Prosedyrer er med andre ord underspesifiserte beskrivelser av hvordan man bør handle (Dekker, 2011). Viktigheten av god improvisasjonsevne er blant annet beskrevet i forbindelse med håndteringen av utblåsningen på Snorre A-plattformen i 2004, hvor noen få nøkkelpersoner klarte å få kontroll over situasjonen gjennom å finne løsninger som på ingen måte var beskrevet i prosedyreverket (Schiefløe & Vikland, 2007, se også Schiefløes kapittel i denne boken). En transformativ lederstil i det daglige kan skape grunnlaget for god evne til improvisasjon. Med andre ord kan en «hverdagsledelse» preget av individuell støtte, delegering og vekt på personlig vekst representere et grunnlag og et utgangspunkt også for god ledelse i mer kritiske situasjoner. De relasjonene som bygges i et mannskap i det daglige, vil kunne representere en ressurs som det kan trekkes på når noe uventet og potensielt farlig oppstår. En fleksibel kombinasjon av lederstiler kan altså også være sentralt når det gjelder håndtering av kritiske situasjoner.

Dette argumentet er i tråd med hvordan Morrell og Capparell (2001) innledningsvis beskriver Shackletons lederstil. De viser hvordan hans innsats med å bygge kameratskap, lojalitet, ansvar, målrettethet og optimisme både i de tidlige dagene av ekspedisjonen og etter at mannskapet fryser fast i isen, var en viktig årsak til at de klarte å håndtere kritesituasjonen de etter hvert befant seg i. I et videre perspektiv harmonerer argumentet også med en av de sentrale påstandene vi finner hos Erik Hollnagel (2014) om at sikkerhetsforskning ikke bare bør fokusere på alvorlige hendelser og studier av hvorfor ting går galt, men også på hverdagslige aktiviteter og hvorfor ting faktisk går bra.

Lederstil og høypålitelige organisasjoner

I tillegg til å beskrive hva sjøfolk oppfatter som god ledelse, er et annet mål med kapitlet å drøfte hvordan lederstil kan innvirke på sikkerheten. Vi kan utdype dette ved å se hvordan ulike lederstiler bygger opp under organisatoriske egenskaper som er funnet å ha betydning for operasjonell sikkerhet. Vi anser at lederstil på et individuelt ledernivå kan påvirke egenskaper på et organisatorisk nivå. I organisatorisk sikkerhetsteori er ledelse anerkjent som en nøkkelfaktor og blant det som er benevnt som en av «de fem store» i denne sammenhengen (Flin et al. 2000). Hvordan ledere opptrer, kan med andre ord ha stor betydning for sikkerhetsklimaet og hva som betraktes som viktig og ønskelig i en virksomhet. I HRO-perspektivet beskrives som nevnt tre brede egenskaper som kan øke påliteligheten til organisasjoner som opererer med høy risiko: organisatorisk redundans, evnen til spontan rekonfigurering og «mindfulness». I tabell 8.1 er disse tre egenskapene satt i sammenheng med transformativ og transaksjonell lederstil.

Tabellen illustrerer at transformasjonsledelse understøtter de organisatoriske egenskapene ved en HRO i større grad enn transaksjonsledelse, men den viser også at elementer i en transaksjonell lederstil kan ha positiv betydning for å ivareta organisasjonssikkerheten.

Tabell 8.1 Mulige sammenhenger mellom lederstiler og egenskaper ved høypålitelige organisasjoner (HRO-er).

		Høypålitelige organisasjoner		
		Organisatorisk redundans	Spontan rekonfigurering	Mindfulness
Transformasjonsledelse	Idealisert innflytelse	×	×	×
	Inspirerende motivasjon	×		×
	Intellektuell stimulering			×
	Individuell støtte	×	×	×
Transaksjonell ledelse	Betinget belønning	×		×
	Avviksstyring <ul style="list-style-type: none"> • aktiv • passiv 	×	Negativ	Negativ

Idealisert innflytelse handler om hvordan kapteinen som rollemodell vektlegger sikkerhet, kollektivet og prioriterer gruppen foran seg selv. Dette vil være en nød-

vendig (men ikke tilstrekkelig) betingelse for alle de tre egenskapene ved HRO-er. God teknisk kunnskap og systemforståelse er en forutsetning for å kunne skape organisatorisk redundans hvor ulike roller eller personer med ulik rang har overlappende kunnskap. Vektleggingen av det kollektive vil også kunne skape rom for at de som faktisk er best egnet til å håndtere krevende situasjoner, får ansvar, og kan også skape takhøyde for å stille kritiske spørsmål til den daglige driften.

Inspirerende motivasjon impliserer vektlegging av lagånd, tydelige mål og høye krav til sikkerhet. Dette kan særlig legge til rette for den kulturelle dimensjonen av organisatorisk redundans, som innebærer både evne og vilje til informasjonsutveksling og etterprøving av beslutninger. Det kan også være et grunnlag for oppmerksomhet på uventede hendelser og evnen til å stoppe uønskede hendelser før de utvikler seg til ulykker – med andre ord «mindfulness» i en sikkerhetsmessig sammenheng.

Intellektuell stimulering innebærer å oppmuntre besetningen til å kontinuerlig vurdere risiko knyttet til egen og andres praksis. Muligheten å oppdage svakheter i systemet før de medfører alvorlige situasjoner, er avhengig av at alle om bord på et fartøy varsler når de mistenker at noe er galt. Det er derfor kritisk at kapteinen som øverste leder legger til rette for nødvendig informasjonsdeling i den hierarkiske strukturen om bord og på den måten sikrer en kollektiv «mindfulness». Han må gjennom ord og handling vise at gruppens beste prioriteres, lytte til individuelle behov, gi støtte og bruke tid på å lære opp sine folk.

Gjennom å søke råd fra sine folk ved å aktivt lytte til fagekspertise skapes det rom for å oppdage systemsvakheter som kan redusere sikkerheten om bord. Dette skaper også et fundament for spontan rekonfigurering, der de med god realkompetanse får handlingsrom for å håndtere farlige avvikssituasjoner. Individuell støtte gjennom delegering og videreutvikling av medarbeiderne vil også være et grunnlag for redundans og vektlegging av realkompetanse i krevende situasjoner. En leder kan ikke bare fokusere på arbeidsoppgavene, men må følge opp enkeltpersoner og vise at han eller hun bryr seg om folkene sine. Uttrykket «lege og sjelesørger» brukes om kapteinsrollen for å peke på viktigheten av at kapteinen er oppmerksom på forhold hos mannskapet som kan påvirke sikkerheten, for eksempel sykdom eller dødsfall i familien hjemme som kan gjøre det vanskelig å konsentrere seg om arbeidet om bord.

Både den kulturelle dimensjonen av organisatorisk redundans og «mindfulness» krever aksept for at man sier fra om forhold som kan øke sårbarheten. For å etablere en slik takhøyde i virksomheten er det nødvendig å kjenne til rammene for akseptert atferd. En felles forståelse for disse rammene kan skapes gjennom aktiv

avviksstyring av prosedyrebrudd og betinget belønning som ros når jobben utføres på en god måte.

Passiv avviksstyring innebærer en lederstil hvor det må en ulykke eller uønsket hendelse til før kapteinen gjør noe aktivt for å rette på situasjonen. En slik reaktiv tilnærming vil ikke være forenlig med HRO-egenskaper, den vil tvert om kunne redusere muligheten for at slike egenskaper utvikles. Det kreves aktiv tilrettelegging for å utvikle slike egenskaper, og en passiv lederstil vil kunne føre til forvitring. En reaktiv tilnærming kan for eksempel innebære en syndebukkmentalitet som bryter med en systemforståelse og en vektlegging av et kollektivt ansvar for sikkerheten.

Ut fra dette kan vi si at kapteinen kan gjøre besetningen i stand til å ivareta sikkerheten om bord gjennom å balansere en transformativ og transaksjonell lederstil. En slik balansekunst beskriver i stor grad hva sjøfolk betraktet som god hverdagsledelse.

Konklusjon og implikasjoner

Costa Concordia-ulykken viser hvor galt det kan gå om operative ledere svikter i kritiske situasjoner. Men det er også et eksempel på dårlig hverdagsledelse. Hvis ledelsen om bord hadde fulgt prosedyrene og seilt i henhold til planlagt seilingsrute, ville de aldri ha gått på grunn. Dette kapitlet har beskrevet hva god ledelse innebærer for sjøfolk. En kaptein må være en synlig og god rollemodell som setter tydelige mål og aktivt korrigerer sikkerhetskritisk atferd hos besetningen. Han må delegere arbeidsoppgaver og inkludere besetningen i driften av båten gjennom å lytte til sine folk og være en omsorgsperson.

Ulike komponenter ved både en transformativ og transaksjonell lederstil kan legge grunnlaget for å skape en pålitelig organisasjon i daglig drift og i kritiske situasjoner. En balanse mellom de to lederstilene kan være en viktig forutsetning for å ivareta sikkerheten om bord. En av de viktigste grunnene til dette er at det skapes en mulighet til å oppdage svakheter ved systemet før de utvikler seg til alvorlige avvik eller ulykker ved en kollektiv oppmerksom tilstedeværelse. Denne evnen kunne ha forhindret at Costa Concordia gikk på grunn. Dette kan også skape grunnlaget for god ledelse og improvisasjonsevne i en krisesituasjon. Det kommer godt tydelig frem i beskrivelsen av hvordan Ernest Shackleton bygde et robust og lojalt lag tidlig i ekspedisjonen og på den måten la grunnlaget for å overleve en ekstremt krevende og langvarig krisesituasjon.

Ledelse kan betraktes som et praktisk håndverk som må læres på lik linje med teknisk fagkunnskap. God ledelse i uventede, alvorlige situasjoner avhenger av et sosialt samspill mellom ledere og mannskap. Et slikt samspill må bygges gjennom

hverdagsledelse. Dette er forhold som også kan vektlegges ytterligere i maritim lederutdanning og trening. Utvikling av det som går under betegnelsen ikke-tekniske ferdigheter, kan være sentralt for ivaretagelsen av maritim sikkerhet. Som et ledd i dette kan det også være behov for vurderingsmetoder for slik kompetanse og utvikling av typologier som beskriver hva dette innebærer i en maritim sammenheng. Denne studien og andre kan være et utgangspunkt for å utarbeide en slik typologi.

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Balancing Safety I and Safety II: Learning to Manage Performance Variability at Sea Using Simulator-Based Training

Abstract: The article explores how simulator-based training of professional maritime deck officers can improve the management of performance variability and safety during critical operations at sea. The research has a qualitative design and is based on observational data from two different training programmes and interviews with simulator instructors and experienced mariners attending these programmes. Learning and performance variability in this specific context is explored through the lenses of Resilience Engineering. The study aims to provide guidance to practitioners and researchers on how to achieve resilient performance. The data illustrates three key aspects in learning to manage variability: the ability to prevent adverse events by recognising anomalies and solve problems in a flexible manner, the ability to define limits of action through shared knowledge and the ability to operate the system with confidence. The results indicate that the simulator offers a necessary backdrop for realistic tasks that forms the basis for experiential learning and joint reflection among professionals. The study demonstrates that history of failure works as a repository for highlighting and improving the skills and confidence needed to deal with situational complexity and to maintain operational variability. Thus, realistic training requires balancing Safety I and Safety II knowledge.

Highlights:

- The work explores simulator-based training of deck officers.
- It aims to discover how resilient performance can be achieved in practice.
- Performance variability is studied through the lenses of Resilience Engineering.
- Experiential learning and reflective practice are essential training tools.
- Effective training rests on balancing Safety I and Safety II.

Keywords: experiential learning; maritime officers; reflective practices; Resilience Engineering; simulator-based training; system variability

1 INTRODUCTION

The maritime industry is still associated with high risk. In 2017, there were 2,712 registered casualties and 94 total losses of ships worldwide (Allianz Global Corporate & Speciality 2018). Despite a steady decline in the number of reported accidents, there is a general concern in the industry that human error may continue to be a major driver of incidents in a situation where the vessels become larger and the commercial pressure is increasing (European Maritime Safety Agency 2018; Allianz Global Corporate & Speciality 2018). The grounding of the cruise ship *Costa Concordia* in January 2012 where 33 people perished (The Italian Ministry of Infrastructure and Transport 2013), the fire onboard the oil tanker *Sanchi* in January 2018 with 32 fatalities (Allianz Global Corporate & Speciality 2018) and the recent capsizing of the frigate *KNM Helge Ingstad* at the west coast of Norway (Accident Investigation Board Norway 2019) exemplify the potential severity of accidents at sea.

Operational safety is influenced by a variety of factors, such as other maritime traffic, weather conditions and technical equipment. Although much navigation is routine for long periods of time, contextual factors might align and create unexpected situations that must be handled promptly. Thus, maritime deck officers must be able to handle variable conditions and be prepared for both the known and unknown. Resilience Engineering (RE) is one of the predominant perspectives in safety research where adaptability in complex sociotechnical systems is emphasised (Patriarca et al. 2018; Woods 2015; Hollnagel 2014; Hollnagel et al. 2006). The expression *resilience skills* points to this ability and has been defined as ‘individual or team skills of any type necessary to adjust performance, in order to maintain safe and efficient operations during both expected and unexpected situations’ (Saurin et al. 2014: 30).

Practical guidance on how to develop such skills has to a limited extent been explored in RE literature (Bergström et al. 2015; Righi et al. 2015; Patriarca et al. 2018). The development of this perspective has to a large degree been theory-driven and has been criticised for little empirical-based knowledge and a lack of practical and operational implications (Righi et al. 2015; Patriarca et al. 2018). This article aims to explore how resilient performance can be achieved in practice. More concretely, we will investigate how simulator-based training can be applied to maintain safety by managing performance variability. Empirically, it is based on a study of training of deck officers who operate a specific computerised system at shuttle

tankers. Simulator-based training allows deck officers to safely test a ship's operational limits through trial and error in a safe environment as close to reality as possible.

The simulated technical system and the related work processes are presented in the next subchapter. The theoretical framework of the study is given in section 2. The organisations' ability to discover and manage unexpected events is described through the lenses of RE with an emphasis on variability and organisational learning. A detailed description of the methodological approach, the qualitative research design and the sampled training programmes is given in section 3. The results are presented in section 4 and illustrate three key aspects in learning to manage performance variability: the ability to prevent adverse events by recognising errors and anomalies and solve problems in a flexible manner, the ability to define limits of action through shared knowledge, and the ability to operate the system with confidence. The results are discussed in section 5. The article concludes by highlighting a set of training principles that may enhance learning of safety critical performance and suggests areas for further research.

1.1 DYNAMIC POSITIONING AT SHUTTLE TANKERS

Dynamic positioning (DP) is a computerised system for automatic positioning and heading control of a vessel controlled from the bridge. DP technology is used in operations when mooring or anchoring is not feasible, when the work requires the ship to follow a moving target or when navigational precision is of prime importance. The work process is characterised by an active interaction between human and computer, where the operator enforces supervisory control and can select different modes and forms of control (Sheridan 2012; Woods et al. 2010; Leveson 2004). The officers operating the DP system must attend system specific training and be certified as DPOs (dynamic position operators) in accordance to industry requirements (International Marine Contractors Association 2016).

A shuttle tanker is a ship designed to offload oil from an offshore oil field and transport and discharge it either to an oil terminal or to another tanker for further transport. Offloading operations require a high degree of accuracy, and the DP system is used to keep the ship within specified position and heading limits, counteracting forces such as wind, waves and ocean currents, as well as forces generated by the propulsion system of the vessel. Input from different sensors (e.g., wind, motion and vertical reference), gyrocompasses, and position

reference systems are used to build mathematical models in the advanced computer system. Based on this information, the system calculates the necessary force to be exerted by the thrusters and propellers for the vessel to remain in position. Deviations from the desired heading or position are automatically detected, and appropriate adjustments are made by the system (Kongsberg Maritime 2014).

Once the DP is activated, the operator’s main tasks are to monitor the system and the environment, enter commands (e.g., to change heading or position), take precautionary actions if something is amiss and be prepared to take manual control of the vessel if the DP is malfunctioning. This study looks at how DPOs are trained to handle the system during offloading operations and the stepwise work process that enables the shuttle tanker to be connected to an offloading unit. Figure 2 shows how a tanker approaches a floating production, storage and offloading unit (FPSO). The process follows a very strict oil field–specific procedure. Table 1 gives an overview of the typical phases and steps performed before, during and after connection to an offloading unit. From 10 nautical miles to connect, the procedure usually takes three to four hours depending on factors such as wind, waves and current. An offloading may take from a few hours to several days, influenced by factors such as hose dimension, pump capacity, amount of oil to be offloaded, disruptions and weather.



Figure 1. An overview of the stepwise sequence where a shuttle tanker approaches an offloading unit to start offloading oil to the ship (copyright: Kongsberg Group).

Table 1. An overview of the typical phases and steps performed before, during and after connection to an offloading unit. Distance to the offloading unit with reference to nautical mile (nm) zone or meter (m)

PHASE	STEP (distance to offloading unit)	DESCRIPTION (time used)
Prearrival	Approaching 10 nm	Prepare to enter field and activate DP
Arrival	At 10 nm	Continue preparations in accordance to distance specific checklists (1.5–2 hrs.)
	10–3 nm 3000 m–900 m	
	At 900 m	Activating the DP system (5–10 mins.)
	900–500 m	Continue approach (30 mins.)
	500 m	DP system test (10–15 mins.)
	500 m to connection position	Move into position to connect (30 mins.)
Connection	Connection position Hawser/hose pick up Hawser/hose connected Step vessel back to loading position	Stepwise connection of hose from offloading unit to ship (10–60 mins.) Start offloading oil
Offloading	At 300 m*	Monitor operation (20 hrs. average**)
Disconnect	At 300 m	Hose/hawser disconnection (60 mins.)
Departure	At 500 m	Deactivate DP system
	500 m–10 nm	Leave field following voyage instructions

* The proximity to the offloading unit will vary.

** An offloading may take from a few hours to several days.

In an offloading position, the bow of the ship is to stay in the green section (visualised in Figure 1), with the stern away from the installation. The ship will rotate in the sector according to wind direction (weather vane) to stay in an optimal position with respect to weather conditions and hose integrity. During the offloading operation, the ship is very close to the offloading unit. An average shuttle tanker is 250 meters long, which means that there is little room for error when staying at a distance at approximately 300 meters. If the bow enters the yellow section, mitigating actions need to be taken to get the bow back into the green section (Figure 1). Risk during offloading relates to changes in weather and wind current, DP system failures (e.g., loss of navigation aids or sensors) or power supply failures. If there are critical system faults, the DP can be disengaged, and the vessel can be controlled manually by the deck officers. In such a case, the operation will be aborted, the hose disconnected, and the vessel steered to a safe distance from the offloading unit outside the installation's 500-meter safety zone. The worst-case scenario is a total loss of engine power where the ship drifts uncontrollably and collide with the installation. In addition to material and environmental

damages and potential production downtime, such a scenario involves a substantial risk for personnel injuries.

2 THEORETICAL FRAMEWORK

The focus of Resilience Engineering is to develop ‘principles and practices that are necessary to enable systems to function in a resilient manner’ (Hollnagel 2014: 183). Four main abilities are highlighted as constituting a resilient system (Hollnagel et al. 2011; Hollnagel 2017): the ability to *respond* to regular and irregular threats in a robust yet flexible manner; the ability to *monitor* what is going on, including its own performance; the ability to *anticipate* disruptions, as well as the consequences of adverse events; and the ability to *learn* from experienced successes and failures. When these abilities are present, an organisation can better control variability, whether it is related to a system’s own performance or the environment and can continue normal operations and rebound after unexpected events (Hollnagel and Woods 2006: 348).

The RE safety perspective differs from more design- and rule-based approaches that aim to build safety through planning in advance rather than by increasing the ability to deal with surprises. Hollnagel (2014) uses the terms *Safety I* and *Safety II* to distinguish between these two views on safety. The Safety I perspective is associated with a preoccupation of things that go wrong. Adverse events are analysed in hindsight to understand what went wrong and to define measures to avoid similar outcomes in the future (Hollnagel 2017; 2014; 2013; 2009). As a supplementary perspective, it is suggested to include knowledge on how and why things go right. This perspective has been labelled *Safety II* (ibid.) and is described as ‘a condition where the number of successful outcomes is as high as possible. It is the ability to succeed under varying conditions. It is achieved by trying to make sure that things go right, rather than preventing them from going wrong’ (Hollnagel 2014:183). The complexity of many sociotechnical systems means that accident causation can be complex and difficult to predict. Learning from things that have gone wrong in the past (in line with the Safety I perspective) has thus some clear limitations in such systems, where there are many possible configurations of factors that can produce accidents.

Safety II represents a perspective that addresses the handling of unexpected events. Hollnagel (2014) underlines that proactive safety management requires an understanding of how a system works and that this knowledge is established by observing patterns and relationships across events rather than simply looking at causes of individual events. Despite Safety I and Safety II being described as two fundamentally different ways of viewing and achieving safety, the two are not mutually exclusive. The safety of the maritime operations in our study displays obvious components of both. On one hand, a shuttle tanker's approach to an FPSO is strictly regulated by detailed operational rules as illustrated by the sequence in table 1. On the other hand, the situational complexity in terms of wind and currents can be high at the same time as the operational margins are quite narrow. This means that the navigators' situational adaptation will be a key ingredient in making sure that things go right, and that safety will depend on an interplay between compliance and resilience. Thus, Safety II plays out within a context of Safety I (Grøtan 2015).

2.1 VARIABILITY

A key issue in RE, and specifically the Safety II perspective, is the importance put on performance variability and the ability of individuals to continuously adapt their everyday work to situational changes to ensure that 'everything goes right' (Hollnagel 2014:137). This view on variability is quite different from the view in, for example, quality control of production processes, where variability is seen as deviations from a quality norm and where the reduction of variability is a goal (Johnson and Kuby 2012). In RE, variability represents necessary adjustments and a basis for safety and productivity (Hollnagel 2014). Resilience is achieved by controlling variability rather than by constraining it.

Most seafarers, regardless of rank, would recognise that their work is characterised by variability. The situational context, for example, weather, work operations and traffic complexity, is constantly changing and can be the source of small and big surprises. The ability to discover and respond to such unexpected events is important for safe maritime operations. This is not to say that performance adjustments might not lead to unacceptable outcomes also. The Safety II view involves seeing performance adjustments as a precursor for both success and failure (Hollnagel 2014).

Other safety perspectives have addressed how variability on the system level can lead to catastrophes. In the normal accidents theory (Perrow 1984), complex interactions of components in a sociotechnical system is seen as something that can lead to errors spreading in unexpected ways, eventually leading to accidents. This is a form of variability that is not immediately comprehensible and thus difficult to control. Functional resonance (Hollnagel 2004) is a concept parallel to complex interactions, where performance variability of components in complex systems can add up and lead to systemic accidents.

In the earlier safety theory, performance variability has also been associated with human error and noncompliance, but this has been considerably nuanced in later years. How operators and decision-makers make sense of changes in the situational context of operations and adapt accordingly has been subject of much research attention (Rasmussen 1997; Hayes 2012). Performance variability has, in many instances, been found to be a human asset that has averted accidents and catastrophes. The Snorre A accident in the petroleum industry in 2004 is one example, where a gas blowout eventually came under control by the efforts of a small group of people performing under circumstances not described by any procedures (Coeckelbergh and Wackers 2007). In other words, work as imagined in procedures might be different from work as done, and variability can in some circumstances be necessary (Hollnagel 2018). This is consistent with 'Model 2' thinking about rules and procedures (Hale and Borys 2013), involving three basic ideas: (1) rules are underspecified and can never cover all eventualities; (2) variations and adaptation of human performance is valuable and necessary; and (3) experience-based, professional judgment is fundamental for safety.

2.2 LEARNING

The fundamental goal of simulator training is learning. Learning is one of the four cornerstones in RE and is regarded as crucial for resilient performance (Bergström et al. 2015; Righi et al. 2015; Hollnagel 2017; Patriarca et al. 2018). Hollnagel (2017: 36) defines learning as 'the ways in which an organization modifies or acquires new knowledge, competencies and skills'. He emphasises that learning is incremental, shaped by previous knowledge and to be understood as an active process of development rather than as a passive collection of facts and knowledge. It is common to base safety training programmes on lessons learned from accidents or incidents in accordance with a Safety I perspective and with an emphasis on

preventing similar errors in the future (Hollnagel 2017). Many RE studies place the capacity to maintain system resilience with activities or skills of sharp-end operators such as deck officers and say this capacity is enhanced by planning or training (Bergström et al. 2015).

Argyris and Schön (1974) claimed that all human action is based on theories of action and differentiated between 'espoused theories-of-action and theories-in-use'. They explained that espoused theories of action are self-reported by people as a basis for their behaviour, while theories-in-use are construed based on observations of how people actually behave. To alter theories-in-use, people must question the framework of theories that form their actions, described as 'double-loop learning' (ibid.). They emphasised that most organisations are characterised by *single-loop learning* where changes only happen at an espoused level. Leadership at sea may be particularly exposed to single-loop thinking since a crew is organised following a strict hierarchy, where the people work together over long periods and where the ship organisation is loosely coupled to the onshore shipping company. Leaders tend to receive little feedback on their behaviour, and followers tend not to question or break their governing norms (Argyris 1976). Simulator training offers a way to counterweight this as an important aspect of simulator-based training is to give officers an opportunity to observe each other's actions and reflect on their practice with peers.

Rudolph et al. (2007) indicated that the goal of simulator training is to allow trainees to explain, analyse and synthesise information and emotional states to improve performance in similar situations in the future. This kind of training follows the four-stage learning cycle proposed by Kolb (1984): Professionals learn by doing (*having a concrete experience*), by thinking about what they are doing (*reflective observation*), by using lessons learned to modify work practice (*abstract conceptualisation*) and by applying what is learned (*active experimentation*). A learning process cannot take place without rigorous reflection from learners and described learning as 'the process whereby knowledge is created through the transformation of experience' (Kolb 1984: 38).

Schön (1995) focused on professionals and their capacity to self-reflect on their actions in a continuous process of learning and improvement. He coined the term 'reflective practice', demonstrating that experience alone does not necessarily lead to learning; deliberate reflection on what drives one's own professional practice is essential. Professional

practitioners get their experience from repetitive action and then build up their *knowing-in-action* through subsequent development of a repertoire of expectations, images and techniques. Over time, the practitioners' knowledge tends to become increasingly tacit, individual, intuitive and automatic and develops as a *reflection-in-action* that will benefit the situation at the time of an event. To change work practice requires *reflection-on-action* where the practitioner revisits an event, think back on what happened and adjust future actions based on this knowledge. We will explore how simulator-based training supports reflective practices and eventually learning.

3 RESEARCH DESIGN

This study uses simulator-based training of professional DPOs at shuttle tankers to explore performance variability and safety at sea. The research aims to generate rich data (Charmaz 2014) from several sources to get an in-depth understanding of this specific training in relation to the research question. The material used in this article is collected over a six-month period. Observations of two specific DP training programmes, interviews with 12 DP instructors and seven course participants are the main data sources. Secondary sources include written documents describing the relevant training programmes, scenario scripts for the simulator exercises, presentation materials used in the classroom and pertinent training requirements for DP operators. The next section gives an overview of the methodological approach and the empirical material. It is followed by a detailed description of the research context.

3.1 METHODOLOGICAL APPROACH

The data is from a Norwegian global company providing a broad range of simulator-based training for mariners. Two different DP training programmes were observed, and relevant information captured in field notes. Both DP instructors and course participants were interviewed. The training and the informants were purposively sampled with the research question in mind. The data gathering followed the principle of saturation (Charmaz 2014) and was concluded when no new insights or patterns were uncovered and when the material was judged as robust.

The 12 interviewed DP instructors worked at four different geographic locations, with a majority (seven) teaching at the same centre in Norway. All instructors held valid deck officer

certificates at the time of the interviews, and their experience as instructors ranged from two to twenty years. The interviews focused on what characterises good simulator-based training and what the instructors emphasised in the debriefing session. The interview guide was sent to the informants prior to the interviews. The conversations were done face-to-face or on Skype, and notes were taken during the talks. Some of the informants provided written answers on e-mail before the interview session. These answers were then discussed and clarified during the talk. The interviews lasted between 30 and 60 minutes. Three of the informants were instructors at the observed training programmes and provided information through informal conversations as well.

Three group interviews, with a total of seven course participants attending three different courses, were carried out. The informants were professional officers, in which two were masters, three were chief officers and two were second officers. All had a valid DP certificate at the time of the interview, with an experience on the system ranging from two to fifteen years. The course participants were asked to describe what characterised simulator-based training that best enabled them to handle errors in the DP system or incidents during DP operations. One interview was with three people. This was audio recorded and later transcribed ad verbatim. The other two interviews were with groups of two, and notes were taken during the talks. These interviews lasted 15–20 minutes. Two of the groups attended training that was also observed, and this allowed for informal talks and some additional data besides what was discussed in the interviews.

The analysis was performed as an iterative process moving back and forth between empirical material and theoretical perspectives in an ongoing construction of meaning following abductive reasoning (Tavory and Timmermans 2014). The data was coded and organised first at a general level, giving an overview of the material, and then more detail codes were used to expand and add new levels of interpretation (Coffey and Atkinson 1996).

3.2 DP TRAINING OF DECK OFFICERS AT SHUTTLE TANKERS

Simulator-based training of deck officers operating the DP system at shuttle tankers is investigated in this study. Two different DPO training programmes described as offshore loading phase 3 and phase 4 were sampled. Both programmes were intended for experienced DPOs and in accordance to the certification scheme recommended by DNV-GL (2014). DPOs

hold the rank of either junior officer, chief officer or master at the tanker where they work. The course participants were thus skilled seafarers. The number of participants in a course was two or three persons. The instructors were experienced mariners who had worked at sea for several years and had in-depth knowledge not only about the technology to be taught but also about the work context. The expressed scope of the programmes was basic knowledge of offloading procedures at specific oil fields and in-depth competence of DP specific equipment and software at the bridge in combination with a general understanding of vessel and environmental factors.

Offshore loading phase 3 is a repetition course with retraining every two years. It is a three-day course (20 hours) focusing on the proper use of procedures relating to different oil fields. The participants are updated on the latest development of DP technology as well as DP incidents and are urged to share their own hands-on experience with the DP system. Non-technical skills such as communication, risk awareness, and decision-making are implicit aspects of the training. Offshore loading phase 4 courses are training programmes developed on request by customers. They have many similarities with phase 3 programmes but offer training on specific offloading systems and belonging field procedures. The observed programme lasted two days (15 hours) and focused on offloading operations at a new FPSO in the North Sea. The course highlighted understanding and familiarisation of the DP software, safety barriers and limiting factors in the system during normal approach procedures.



Figure 1. Layout of a bridge simulator (copyright: Kongsberg Group)

Both programmes combined classroom lectures and practical exercises. The length of the lectures and the simulator sessions varied with training objectives and the course participants' level of experience. The bulk of the training was performed in full-mission ship bridge simulators (Figure 2). Here, the physical layout of an actual bridge is combined with hydrodynamic forces and digital projections providing up to a 360-degree virtual view of the ship's surroundings (e.g., other vessels, harbours and weather conditions). A simulator session typically started with a briefing, followed by a simulator exercise, and ended with a debrief. Figure 3 gives an overview of the main elements in the training.

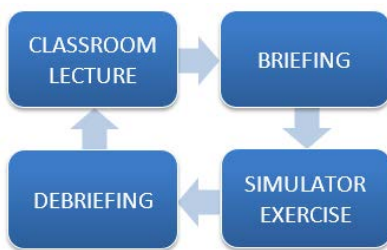


Figure 2. Overview of the main phases in simulator-based training for professional maritime officers

The classroom lectures were intended to give in-depth knowledge of the DP system and prepare the attendants for the simulator exercises. The length of the lectures depended on the course participants' prior knowledge and were generally longer in the phase 4 training since this was a new field where none of the participants had sailed before. In the briefing, the instructor reviewed the tasks to be performed in the simulator and explained to the course participants what is expected of them and the purpose of the simulation with respect to learning objectives. The simulator exercises in the phase 3 programmes typically went on nonstop for one and a half to two hours, with a minimum of one simulator session in the morning and one in the afternoon of each course day. The phase 4 programme had longer simulator sessions with several breaks, allowing for one session each day. The debriefing usually followed immediately after the simulation and was characterised by discussions in which the attendants revisited and explained actions that took place during the exercises. The debriefing lasted from a few minutes to an hour. It usually lasts longer if the lack of knowledge

or skills were uncovered in the exercise. Sometimes, parts of the classroom lectures were repeated or explained in more detail during the debriefing to cover knowledge gaps.

4 RESULTS

The simulator training programmes emphasised routine offloading operations, and the main goal was to learn to handle unforeseen events or errors before they develop into an uncontrollable situation. The simulator exercises, the debriefings and the instructor are instrumental in this training process. The analysis identified three key aspects in learning to manage performance variability: the ability to prevent adverse events by recognising errors and anomalies and solve problems in a flexible manner, the ability to expand limits of action through shared knowledge and the ability to operate the system with confidence.

4.1 RECOGNISING ANOMALIES AND SOLVING PROBLEMS IN A FLEXIBLE MANNER

The DP training was designed to mirror real work tasks performed at the bridge during offshore loading. This made the training lifelike and gave the instructors an opportunity to introduce errors and anomalies in the system that the DPOs should detect and mitigate. The informants stressed the importance of realistic errors in this kind of training. According to the informants, the worst-case scenario is a total loss of power and a ship drifting uncontrollably. The deck officers are obliged to learn to handle such a scenario adequately, even if the chance that it happens in real life is small. It is more likely to have minor errors that can cause big problems if left undetected. One of the DPOs put it like this: 'It is often minor errors that triggers a large accident or a serious incident.' Another DPO emphasised that it is important to learn to recognise nuances in the system to detect anomalies as early as possible. This may not only prevent things from going wrong but also buys time to consider mitigating actions. One DPO said, 'It is important not to act on impulse, but to take one step back, take a few breaths and think'.

The simulator exercises were based on known frequent errors or adverse events that may happen while operating a DP system. An instructor explained how he uses 'incident reports to link what is done in the simulator to the real world, demonstrating the worst possible outcome of actions'. In this case, the scenario intends to replicate a chain of events described in the report, and the goal is to enable the participants to identify problems at an early stage and

take actions that will lead to a different trajectory than the actual accident. Although this was regarded as valuable input to the learning process, the instructors explained that it is more common to address known typical minor system weaknesses or frequent errors in the simulator sessions (e.g., problems with reference systems, sensors or gyros). The instructors described these errors as minor fluctuations or variations in the system that an operator should be able to detect and contain to maintain safe operations. The DPOs valued the focus on system deviations rather than emergency situations. One of them explained, 'It is only so much you can learn from practising total loss of engine power, then there is only one solution. You also need to learn to recognise minor deviations and how to handle these, for example what to do if you lose one of the wind sensors'. The simulator was regarded as a unique opportunity to identify limitations of the DP system and to find solutions to problems that the DPOs may encounter on board. The DPOs broadened their understanding and repertoire of actions by testing different solutions to the simulator tasks in a learning-by-doing manner to the effect of 'if I do like this, what happens then?'

Several of the instructors used the term 'hot debrief' to describe how they sometimes take a time-out or stop the exercise momentarily to guide the course participants during a scenario. It is a short break, lasting a few minutes, where the instructor joins the officers at the bridge to clarify or correct something. The instructors explained that this may be done when trainees are unfamiliar with procedures or equipment available in the bridge simulator. This hands-on adjustment of the technical knowledge or skills needed to perform the tasks was frequently used. Another reason for conducting a hot debrief was when the trainees made serious mistakes that may lead to an unlikely or unwanted outcome of the exercise. The instructors highlighted the importance of a time-out to get the trainees back on track and maintain the realism in the scenario to meet training objectives. According to the instructors, the officers' ability to correct errors and handle the system may become better if you stop the exercise and explain what is about to happen, allow for some time to reflect and maybe redo actions instead of letting the ship to run aground or the engine room fire to get out of control. This opportunity to freeze a scenario and reflect on different actions while still in the situation was regarded a strength.

The instructors emphasised that the learning outcome benefits from discussing rationales behind what went well and what went wrong during the exercise during the debriefing. An instructor sums it up like this: 'Recognise what they did good, which errors were identified. Were there any minor deviations that could have been corrected early on or did they allow them to escalate? Could the task have been handled differently?' Several of the instructors highlight that the tasks resolved in a manner both below and above standards may have had a different outcome if the conditions had been slightly altered. Thus, a key aspect in the debriefing is to discuss if there could have been different possible options and actions even if the exercise was successful.

4.2 DEFINING LIMITS OF ACTION THROUGH SHARED KNOWLEDGE

The observed simulator sessions focused on exercises specific to offshore loading and emphasised operator compliance to industry guidelines and requirements. The exercises typically contained a set of tasks to be solved by the course participants in which the goal was to perform the job within the limits set by procedures and checklists. This line of work is strictly governed by detailed work descriptions as shown in the introduction, and the main purpose of the training is to learn to follow the procedures applicable to a certain oil field or part of an operation. Still, the procedures are regarded as a flexible frame of action. One of the instructors explained that 'there are many ways to solve the tasks satisfactory – despite checklist and procedures'. Both instructors and course participants expressed that they were sometimes surprised by the actions of others and how they choose to solve a problem. This indicated that there is room and need for operator discretion even in this rule governed trade.

The debriefing is designed to give the trainees an opportunity to reflect and actively take part in evaluating different ways to approach a solution. One of the instructors said that 'the debrief period can often be half of the learning experience even though it typically only takes about 10% of the time spent on an entire simulator session'. The core of the debriefing is to explore frames of action that influence team and individual performance during the simulator tasks and to bridge what is learned during simulator scenarios with actual work. It is described as an important element in the training of all informants. It revisits key events in the simulator exercise and is used to explore and discuss the outcome of chosen actions. An instructor reported that 'during the debriefing I mention my perception of the student's actions, or lack

thereof, then I ask the students to show me their point of view, saying why they took that action – whether this action is correct or not – and what led them to interpret the fault in that way. After that I try to explain to them what the fault caused to the system and why their action was or was not the best one’.

One of the instructors explained that he ‘coaches participants to actively reflect or ask questions’, and even if his role is to instruct, ‘students can in many cases learn better from fellow participants’. Another instructor upheld that ‘sharing experiences among the participants is just as important as the opinions of the instructor’. The instructors jointly described their role as a facilitator or mentor rather than a teacher during the training programmes. Many of the trainees were considered highly knowledgeable officers, and according to the instructors, they could learn a lot from each other if this was facilitated. If they actively shared their knowledge and experiences from real work situations, it could expand the action repertoire and skills of the entire group, in addition to reinforcing already-existing good practices. The instructors emphasised that they themselves often learned from the course participants. The trainees are experienced professional officers, and their knowledge about how work is performed onboard helps translate theory to real work situations. Their descriptions of technology or systems in use at their vessel and the strengths and weaknesses of the system during normal or critical operations indicate topics that need to be addressed and included in the training not only in the course they are attending themselves but also in future programmes.

An aspect of the training highlighted by the instructor and evident in the observations was the intention to develop the course participants’ ability to self-assess not only during training but also in work settings. To evaluate oneself, the decisions made, and the actions taken are highlighted as important skills at sea by the instructors, as well as understanding frames of actions and uncovering errors at an early stage and containing them before they evolve into an uncontrollable situation.

4.3 OPERATING THE SYSTEM WITH CONFIDENCE

The observations and the interviews made it evident that building confidence as a system operator was an inherent part of the training. Several mentioned that to perform well as a DPO, you must feel safe in unusual contexts. This is partly accomplished by detailed knowledge

of the DP system and the vessel so that a DPO can trust the system to perform in accordance to supervisory control. This feeling, however, also comes from a DPO's level of assertiveness and trust in one's ability to control the system. An instructor explained that 'the goal is that they should feel more confident and not be nervous while operating the DP'. It was interesting to note that disengaging the DP and manually handling the vessel was one of the learning objectives in the training aimed at reducing possible uneasiness. One of the participants described it like this: 'We get to test and do things that you usually do not do onboard, for example manual manoeuvring. The simulator gives you an impression of how it will work, then you don't have to worry about something going wrong when back on board.' One of the pitfalls in being used to and becoming confident with the DP system is that a DPO gets less experience with 'hands on' control of the ship. The instructors explained that it is essential that a DPO can handle the vessel manually. In a worst-case scenario where the best option is to disengage the DP, the DPO must do so without hesitation. Lack of confidence or doubting one's own abilities can cost valuable seconds in an emergency and cause the ship to collide with the installation.

The phase 4 programme exemplified how the training is designed to build a DPO's level of confidence with the step-by-step offloading operation. The training started with a classroom lecture on the characteristics of the new field emphasising similarities and differences with other familiar fields. The stepwise sequence from 10 nm to connection and the options for staying in position during the offloading were described in detail by the instructor. The course participants were encouraged to ask questions and raise concerns during the entire lecture. This session usually lasted two to three hours, and it served as a preparation for the simulator training that started after lunch. The first simulator session lasted the rest of the day (three to three and a half hours), allowing for a short debriefing at the end to wrap up the first day. The simulation was frequently stopped during this period, not only for the DPOs to take breaks but also to ask questions or discuss actions, test the equipment or clarify system warning or alarms. On the second day of training, the DPOs were asked to request scenarios or tasks they would like to practice. This flexible schedule was emphasised by the instructor as vital to close knowledge gaps and to reduce uncertainties about the field or the DP system in general.

The programmes also allowed for requests from the participants to tailor the training to their needs, either to go more detailed into specific parts of the theory or to train certain skills or

aspects of the DP operation in the simulator. This flexibility was appreciated and expected. One of the DPOs explained, 'I like to bring some questions with me to the phase 3 training. If I have noticed something while onboard that that I want to check with the instructors or in the simulator, I make a note of it and raise the question or test it during training'. The instructor emphasised the importance of having a flexible schedule with ample room for the participants to ask questions and raise concerns to expand their knowledge and build confidence.

The instructors emphasised the importance of establishing a sense of achievement throughout the training. Some instructors used the hot debrief as a time-out to avoid the trainees from making a fool of themselves. One said, 'It is wrong to watch people do mistakes that they will be ashamed of after the training.' It was considered better for the learning process to give some guidance and help during the exercises than to wait until the debriefing to point out weaknesses and poor decisions, with one exception: if a course participant had a cocky attitude or displayed overconfidence that caused unnecessary risk, it was regarded as 'OK to give them difficult tasks where they would fail'. Overconfidence was regarded just as dangerous as lack of technical understanding by the informants. Several of the instructors mentioned that technical-brilliant but complacent DPOs can be difficult to teach. It may be difficult to address their weaknesses during training, particularly if the person is a senior captain and the instructor is more of a junior: 'Depending on level of rank or age they may take it personal, a captain will not listen to critique from a junior.'

The training was characterised by joint discussions and reflection among the course participants during simulations and in the debriefing sessions. Peer feedback was highlighted as an effective method to correct unwanted actions or attitudes, especially if the participants held the same rank or if seniors corrected junior officers. What was observed to be more problematic was if the most senior participant was defensive or indifferent to others' feedback. Most instructors had experienced a course participant pulling rank and not being open to the input of others and described how this would have a negative effect on the training outcome for all participants. One of the instructors explained, 'For me a good debrief establishes confidence in each delegate, makes them feel like they are heard and promotes their desire to learn more and pay attention to the details'.

5 DISCUSSION

The aim of this study is to explore how simulator-based training of professional maritime deck officers can be applied to manage performance variability and maintain safety during critical operations at sea. Learning is regarded as crucial for resilient performance and is one of the four cornerstones in RE (Hollnagel et al.2011; Hollnagel 2018). The theoretical framework presented in Chapter 2 indicates that the practical guidance on how to develop these skills has been little explored in RE literature (Bergström et al. 2015; Righi et al. 2015; Patriarca et al. 2018). In the following discussion, we want to examine performance variability in a Safety II perspective (Hollnagel 2014) and provide guidance to practitioners and researchers on how to achieve resilient performance based on the results in this study.

5.1 MAINTAINING VARIABILITY THROUGH EXPERIENTIAL LEARNING AND REFLECTION

The handling of variability is an important safety issue in RE. Under complex and changing conditions at sea, it is essential that navigators can respond and adapt adequately to expected and unexpected situations. This is what performance variability is about; it involves the adaptation of work performance to situational changes. As a theoretical concept, it builds on the law of requisite variety from cybernetics, stating that ‘variety can destroy variety’ (Ashby 1956: 207). In other words, the regulation of external variability can be achieved by a matching internal (performance) variability. Performance variability can be regarded as an operator’s ability to regulate performance to maintain safe and efficient operations during both expected and unexpected situations and has been described as resilience skills (Saurin et al. 2014). It is widely recognised that the development of skills requires training. Simulator-based programmes seem to have several features that make them suitable for training the skills needed to manage performance variability.

Simulators can generate a realistic and safe training environment to practice hazardous work, creating an important link between the development of skills and the operational context in which the skills are to be applied. Earlier studies have pointed out the importance of simulator-based training to reduce risk in the maritime domain (Crichton 2017; Hontvedt 2015; Håvold et al. 2015; Hontvedt and Arnseth 2013). Technological development has made it possible to create advanced computer-generated training environments that replicate the real world at a

very detailed level (Dahlstrom et al. 2009; Liu et al. 2009). Wahl (2019) coined the term 'social fidelity', indicating that an exact replication between the simulated and the actual physical entities of a bridge is not always necessary to realise training goals; rather, it emerges in the interaction among the simulator, the course participants and the instructor. The data material indicates that the simulator exercises alone will not provide learning of resilience skills. The simulator offers a necessary backdrop for lifelike tasks but is not a sufficient condition for learning. Learning among professional officers also requires reflection and feedback from others.

The social aspect of the simulator training enhances reflection and strengthens learning. By joint discussions involving peers and instructors, new solutions and practices can be made available, as well as considerations of current, individual practices. The collaborative setting of simulator training is well suited for reflective practice (Rudolph et al. 2007; Schön 1995). Our analysis illustrates that learning occurs when the trainer and the trainees jointly explore the frames of action that leads to the actual performance in the simulator and develop new frames for action together. The deck officers did not only learn about the DP technology but also learned skills in handling the sociotechnical system from each other. Thus, it is valuable that experienced, professional officers from different ships or companies train together. The training gives the DPOs an opportunity to develop a repertoire of actions for handling variations in the DP system. Testing the system limitations in the simulator and reflecting on their actions with peers expanded their understanding and strengthened their ability to adapt to novel situations with the right level of confidence.

Different opportunities for reflection were provided during the training. It is interesting to note that the use of a simulator provides the opportunity to 'freeze time' either during a training session or by reviewing recordings of certain decisions made after a session. The hot debrief was applied in our case as a time-out for reflection during exercises, in addition to conventional debriefs after sessions. The hot debrief can be regarded as both a *reflection in action* and *reflection on action* (Schön 1995). The time-out allows reflection on what is happening in the simulated situation, and at the same time, it involves reflecting on how practice can be changed in future operations on board. Reflection was also described as the main rationale for the debriefing. The instructors emphasised the importance of dialog during

debriefing and described their role more as facilitators than teachers. Facilitation involves bringing the participants' experiences and knowledge to the forefront and integrating the different views of the participants (Wong 2005). The data material revealed that the instructors encouraged asking questions and active reflection during debriefing and that sharing of experiences was important.

The opportunity to observe other DPOs' actions and later discuss what was observed may also be valuable for *double loop learning* (Argyris and Schön 1974). Theories-in-use can be derived from observing actual behaviour in the simulator and used to nuance or counteract espoused theories verbalised in the briefings or debriefings. Thus, the training may challenge established theories of action and give the officers direct feedback on actual behaviour. The simulator training also provides an opportunity for experiential learning (Kolb 1984). The design of the training programmes lets the course participants think about what they are doing, modify their practice and to apply what was learned in the next simulator exercise. This rigorous reflection and immediate tryout of the lessons learned allows knowledge to be created through the transformation of experience.

Simulators provide an opportunity to enact events that rarely happen in real life. They give the chance to test actions and decision-making during the exercises, as well as set focus or aid discussions in the debriefing sessions. Even if it is not likely that the deck officers will encounter the exact same scenario in real life, they train their overall ability to anticipate, monitor and respond. Training for events with low probability but high consequence can add to a general repertoire of responses that can be useful across different situations. Here, learning does not only mean learning to respond to specific system errors; rather, the DPOs train their ability to recognise and respond to system errors in general and to apply this knowledge in different situations.

5.2 BALANCING SAFETY I AND SAFETY II

We do not view Safety I and Safety II as a question of choosing one over the other. This was underlined early by Hollnagel (2014: 178) who emphasised that Safety II is 'intended as a complement to Safety I rather than a replacement of it'. The contrast between them is a pedagogical way of highlighting different capabilities needed to maintain safety under different operational conditions. In empirical accounts of safety practices, the boundaries

between the two concepts become far more blurred. In our data, three examples of this may be highlighted.

First, the simulator training is based on scenarios constructed from previous errors and accidents that belong to the Safety I paradigm. However, they are used to improve skills related to Safety II. When the participants play out the accident scenarios, they are experimenting with different ways of handling situational complexity in a flexible way, which draws more on Safety II than Safety I. In this way, the history of failure works as a repository for highlighting and improving the skills and confidence needed to deal with situational complexity.

Second, the need for balancing between Safety I and Safety II is apparent in the way the level of situational complexity can change rapidly when a shuttle tanker approaches a FPSO. Wind, waves, ocean currents or technical failure in the DP system may change the operational limits during off-loading. If we accept the premise that situational complexity is not a static property of a system or an activity, the implication is that the need for Safety I and Safety II strategies may vary accordingly. If the situational complexity is low, a Safety I-based approach would be sufficient to maintain control over the hazards involved, although small adaptations will occur also in these conditions. The operational complexity may, however, increase in an instance, calling for a more resilience-based Safety II approach¹. As Safety II has to do with the ability to succeed under varying conditions, the 'varying conditions' include both the conditions where situational complexity is high and calling for flexible adaptation *and* the conditions where rule-based approaches would be enough to remain in control over the situation. The key point in this respect is the ability to recognise the variability and the need for adaptation and the actual skills needed to make these adaptations. This can be pivotal mode-switching moments² where the difference between success and failure can be marginal. More importantly, this is not an elusive system property; it requires both technical and non-technical skills among the operators involved in the operation. This skill must come from somewhere, and we argue that

¹ The way sudden increases in situational complexity influences safety has been previously described in Weick's analysis of the Tenerife aviation disaster (Weick 1990).

² This way of reconfiguring the operational approach to deal with increases in complexity has been previously described by several HRO researchers (e.g., LaPorte and Consolini 1991).

simulator training can be a way of increasing the operator's repertoire for dealing with such situations.

The third, and on a related point, is that simulator training needs to be tailored towards the balancing between Safety I and Safety II to have the desired effect. In our data, the instructors emphasise the importance of a dual focus on the participants' errors and increasing their ability to recognise and reflect on the conditions contributing to success. The hot debrief approach allows for taking time-outs as the training proceeds to highlight pivotal moments in which complexity and the corresponding need for performance variability to deal with unexpected situations are both increasing. The debriefing sessions provide additional opportunities to explicate and generalise such lessons. These sessions are also unique opportunities to shed light on the relationship between work as imagined and work as actually done (Hollnagel 2018), providing an occasion to consider practical drift (Snook 2000), increasing awareness of the limitations of safe operation and reveal needs for adjustment in work procedures.

6 CONCLUSION

The data material demonstrates how simulator-based training of professional deck officers can be used to manage performance variability. It is important to note that these effects are not automatic results of simulator training. They are the possible effects of a training philosophy that is designed to address the balancing between Safety I and Safety II. Our advice would not only be to do more simulator training but also to use the opportunity better by recognising it as fertile ground to increase the skills and capabilities needed.

The DPOs' capability to control variability depend on their ability to anticipate, monitor and respond to system errors. These abilities are the core of resilience skills. The results indicate that deck officers learn these skills through joint reflection and experiential learning triggered by realistic simulator exercises. It is important to note that realistic training is not limited to a focus on adverse events and emergency handling but must include mundane tasks and minor errors so that operators can learn to catch and contain minor errors before they evolve into uncontrollable situations.

The data indicates that simulator training allows for reflection both *in* and *on* practice and gives a unique opportunity to discover discrepancies between *work-as-imagined* and *work-as-done*. The debriefings let the trainees and their trainer jointly reflect on what went well and what went wrong during the simulator sessions. The reflections do not only draw on what happened during training but also depends on each participant's level of experience and his or her successes or failures at sea. This demonstrates the importance of debriefing as a learning tool. It may be valuable to study this aspect of simulator-based training more, for example, how to structure and facilitate these sessions to support the needed reflection and sharing of experience among professionals.

This study shows that Safety II, to a large extent, builds on the operator's ability to train their resilience skills. This moves the RE perspective from a system to an individual level. The advantage of regarding resilience as a skill is that it becomes more tangible and something an organisation can achieve through training of key personnel. It can be argued that this moves the perspective from a theoretical stance to a more applied approach. We think this approach may be beneficial also in further studies, not only in the maritime domain but also in other high-risk industries such as aviation or health care.

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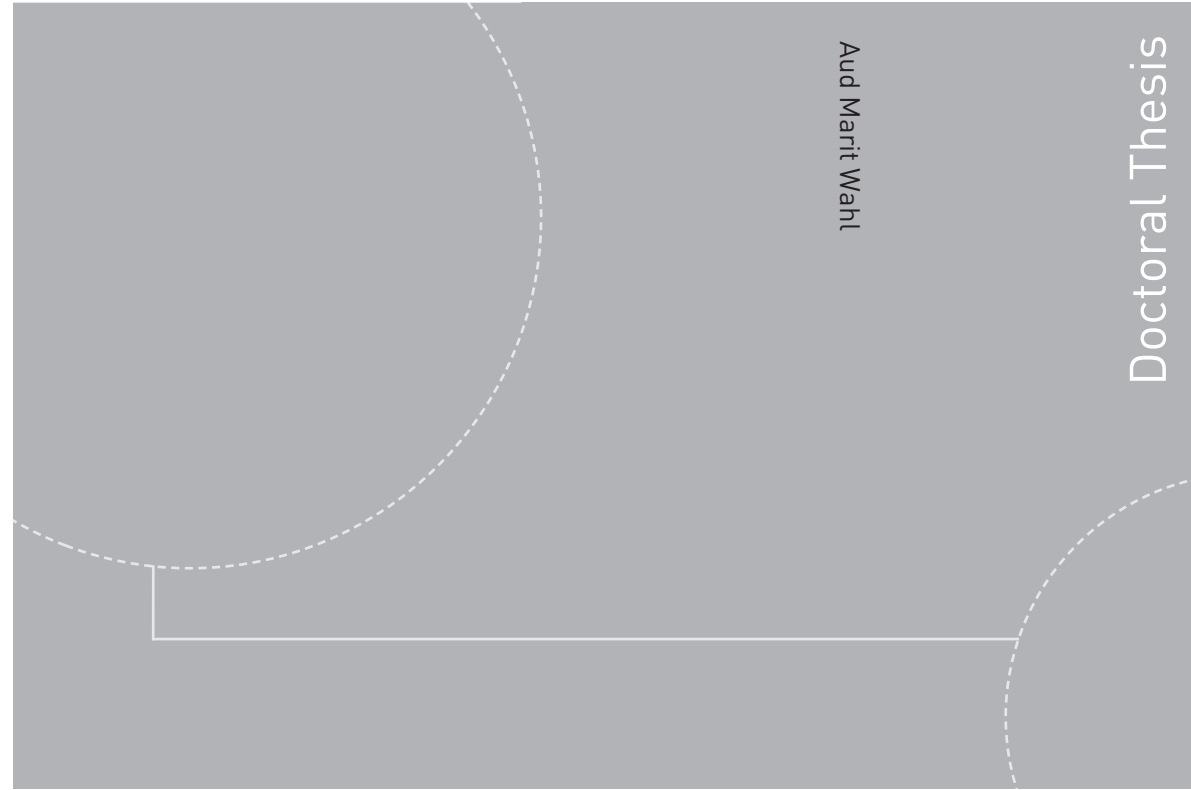
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