

# **Safety on board offshore vessels: A study of shipboard factors and situation awareness**

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## Scientific environment

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The doctoral work was carried out within the context of the general PhD programme and the Graduate School of Clinical and Developmental Psychology, Faculty of Psychology, University of Bergen. My workplace has been Western Norway University of Applied Sciences, Department of Maritime Studies, throughout the whole project period.

My main supervisor has been Helle A. Oltedal, Western Norway University of Applied Sciences, Department of Maritime Studies. My co-supervisors were Sigurd W. Hystad and Jarle Eid, University of Bergen, Faculty of Psychology.

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## Abstract

The overall aim of this thesis is to shed new light on how shipboard factors may influence the ability to achieve and maintain situation awareness (SA) in day-to-day operations on offshore vessels. The term, 'shipboard factors' refers to factors in the internal environment on board the vessel, such as work practices, on-board leadership and job demands. Situation awareness is seen as a cognitive process in the individual but also as a distributed characteristic of a complex collaborative system. The thesis consists of three studies, in which we have used three different methods to explore the overall aim of the thesis.

The first study, and our point of departure, aimed at identifying human, technical and organizational factors that may have influenced loss of SA in previous accidents at sea. In order to investigate this issue, accident reports (n=23) concerning collisions between offshore vessels and offshore facilities on the Norwegian continental shelf during the period of 2001 to 2011 were analysed. The first part of the study revealed that the collisions were preceded by a loss of SA on the bridge in 18 of the 23 instances. In the second part of the study, the human, technological and organizational causes described in the accident reports were analysed to evaluate how they may have affected the bridge crews' awareness of the situation. The results indicate that inadequate operation planning, communication failure, interrupting/distracting elements, inadequate design and insufficient training were the most common factors that may have contributed to the bridge crews' loss of SA.

In the second study, we used a fieldwork approach to examine how safety critical aspects of shipboard operations, such as planning practices, communication practices and management of disturbing/interrupting elements, identified in Study 1, play out in real time on board offshore vessels. By means of fieldwork on board four different platform supply vessels, the study aimed to discuss how shipboard practices relative to these matters may affect transactions of SA-related information between different agents on the bridge such as the officers and various technological tools on the bridge. The study thus favours a systems approach to studying SA, viewing it not

only as a phenomenon that solely happens in each individual's mind but rather as something that happens between different agents such as the officers and the tools that they use in day-to-day operations. The study revealed noticeable variations in shipboard practices. In Article II, we point to the following observations as being inappropriate, from a SA perspective: planning and completion of checklists as an individual activity, limited use of standardized and close loop communication, and interruptions/distractions caused by other crew members, electronic devices and administrative tasks. We discuss how these practices may affect timely and adequate transaction of SA related information from the environment and, in that way, influence the ability to achieve and maintain SA in day-to-day operations.

In the third study, we used survey data to examine how on-board leadership and psychological job demands combine and influence SA and the willingness to take a risk in day-to-day operations. To this end, a conceptual model was developed and tested on survey data collected on board offshore vessels within a Norwegian controlled shipping company. The model was tested in both the deck department (n=178) and the engine department (n=103). With regard to SA, 21.6% of the variations could be explained by the combined influence of authentic leadership, laissez-faire leadership and job demands in the deck department sample, whereas 27.5% of the variations in SA could be explained by the two leadership styles alone in the engine department sample. Job demands and SA explained 18.9% of the variations in risk-taking behaviour in the deck department sample, whereas these two variables explained 30.8% of the variations in the engine department sample.

Taken together, the three studies shed new light on how various shipboard factors may influence the ability to achieve and maintain SA and safe behaviour in a complex collaborative work environment such as bridge operations on offshore vessels. In particular, the study provides insights into how planning, communication and management of distracting/interrupting elements are realized in bridge operations; it also notes possible areas for improvement to enhance SA. In addition, the study expands our understanding of how active and passive leadership styles may

combine with psychological job demands to influence SA and safety outcomes in maritime operations.

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## List of publications

Sandhåland, H., Oltedal, H., & Eid, J. (2015). Situation awareness in bridge operations—A study of collisions between attendant vessels and offshore facilities in the North Sea.

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## Abbreviations

AIS	Automatic Identification System
CD	Coefficient of Determination
DP	Dynamic Positioning
DSA	Distributed Situation Awareness
ECDIS	Electronic Chart Display and Information Systems
G-OMO	Guidelines for Offshore and Marine Operations
GPS	Global Positioning System
IMO	The International Maritime Organization
ISM	The International Safety Management Code
PSV	Platform Supply Vessel
SA	Situation Awareness
SOLAS	The International Convention of the Safety of Life at Sea
SRMR	Standardized Root Mean squared Residual
STCW	The International Convention on Standards for Training, Certification and Watchkeeping for Seafarers

# 1 Introduction and theoretical framework

This thesis examines how shipboard factors may influence the crews' ability to achieve and maintain situation awareness (SA) on board offshore vessels. The term, 'shipboard factors' refer to factors in the internal environment on board the vessel, such as work practices, on-board leadership and job demands. SA is seen not only as a cognitive process in the individual but also as a distributed characteristic of a complex collaborative system. To set the agenda, a brief introduction is provided, along with the theoretical foundation for the thesis.

## 1.1 Background

In general, seafaring involves the risk of grounding, capsizing and colliding with other objects such as other vessels, bridges, quays and offshore facilities. Studies conducted within the maritime industry show that accidents involving loss of SA are frequent (Barnett, Gatfield, & Pecan, 2006; Grech, Horberry, & Smith, 2002). Most common SA is then defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1995, p. 36). It follows, from this definition, that the seafarers either missed relevant information, failed to comprehend the information or failed to project future states relative to their goals.

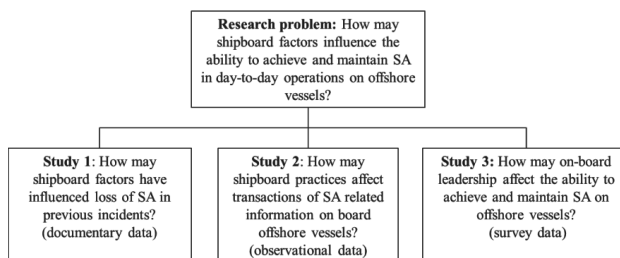
Platform supply vessels, anchor-handling vessels, stand-by vessels, various subsea vessels and shuttle tankers – all categorized as offshore vessels – are indispensable actors in the oil and gas industry. Because the environment on board offshore vessels is dynamic, it is a prerequisite that SA is maintained according to the changes in the environment. From the perspective of the bridge crew, this requires continuous attention towards both the internal and external environment. It also requires that the bridge crew has a well-developed understanding of the system in order to be able to comprehend and project future states. Since the loss of SA has been shown to be an important factor in previous accidents and incidents at sea, the maritime industry may

improve safety by facilitating conditions on board the vessels that maintain and improve SA. Empirical research on how shipboard factors may influence SA is still needed, and this thesis contributes to this end. The research purpose and the research problem are further outlined below.

## 1.2 The research purpose and research problem

The overall aim of this thesis is to shed light on the following research problem: How may shipboard factors influence the crews' ability to achieve and maintain SA in day-to-day operations on offshore vessels? By means of several data sources (i.e. accident reports, observational data and survey data) and various methodologies (i.e. documentary study, field studies and statistical analysis), the thesis illuminates the theme from multiple angles.

The genesis for the thesis was an initial analysis of a selection of accident reports concerning collisions between offshore vessels and offshore facilities. The analysis indicated that human error caused by loss of SA was an important contributing factor to the collisions. However, in order to understand the process that led to the collisions, it is necessary to see these findings in light of factors that have influenced the bridge crews' ability to achieve and maintain SA. A reanalysis of the accident reports is thus aimed at identifying factors that might have contributed to the loss of SA in the course of events (marked "Study 1" in Figure 1).



*Figure 1: Research questions and design*

Acknowledging that accident analysis is based on historical data, the next study aimed to examine how shipboard practices such as planning practices,

communication practices and management of disturbing/interrupting elements, which had contributed to loss of SA in Study 1, played out in day-to-day operations (marked “Study 2” in Figure 1). In this study, we favoured a systems approach to studying SA, viewing it as a distributed phenomenon that happens between different agents in the system. In that way, Study 2 aimed to provide a discussion on how shipping companies may improve shipboard practices in order to facilitate SA. Since Study 1 did not reveal any information about how on-board leadership had influenced the course of events, a theoretical model on how the leadership style of masters and psychological job demands may combine and influence SA and safe behaviour was developed. Our theoretical model was tested on survey data from a selection of offshore vessels (marked “Study 3” in Figure 1). Hence, the overall thesis contains three studies, each of which, in its own way, has aimed to examine shipboard factors that may influence the ability to achieve and maintain SA on board offshore vessels.

Taken together, the following research aims have directed the research:

- I. Identify human, technical and organizational factors that have influenced loss of SA in previous accidents at sea (results presented in Article I)
- II. Examine how contributing factors to loss of SA (as presented in Article I) play out in day-to-day operations (results presented in Article II)
- III. Examine how leadership styles of masters influence SA in day-to-day operations (results presented in Article III)

This thesis is important because there are relatively few empirical studies on SA conducted within a maritime context. To our knowledge, none of the previous studies has examined how shipboard factors may influence the seafarers’ ability to achieve and maintain SA. This thesis will thus provide new knowledge that has both practical and theoretical implications. It has practical implications in that the maritime industry may use the findings to facilitate conditions that improve SA on board vessels. It has theoretical implications because it adds to our understanding of SA as a distributed phenomenon and provides new knowledge about factors that may influence our

ability to achieve and maintain SA. The practical and theoretical implications of the thesis are further outlined in Sections 6.1.1 and 6.1.2.

## 1.3 System description

### 1.3.1 The bridge

The design of both the bridge and the technical equipment on the bridge are essential factors that will affect the bridge crews' ability to achieve and maintain SA (Endsley, 2012). Offshore vessels, however, are designed to support the oil and gas industry with a wide range of tasks. The bridge and equipment design will therefore vary, according to the type of vessel in question. However, to give the reader an idea of the physical environment on board an offshore vessel, Figure 2 provides an illustration of a typical bridge on board a platform supply vessel (PSV).

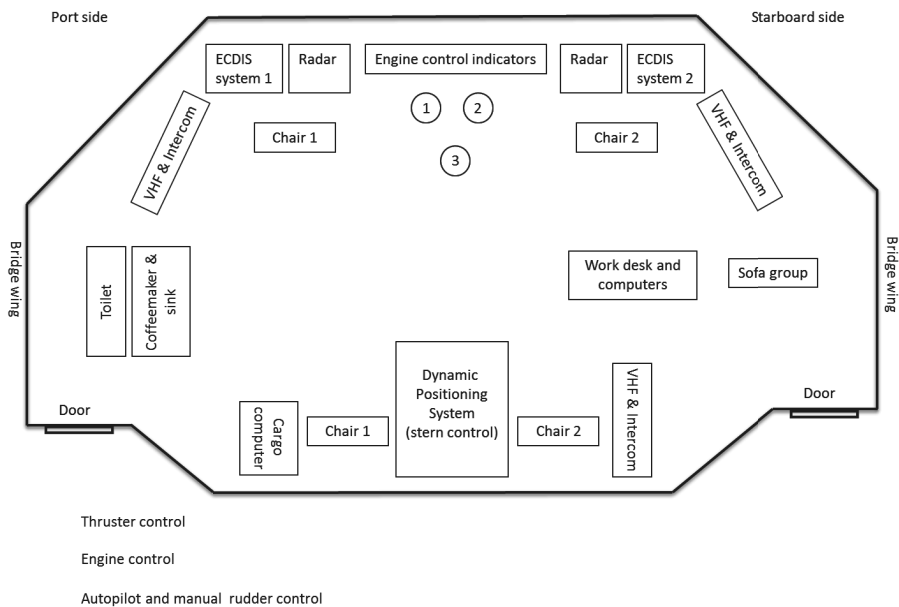


Figure 2: Sketch of a typical bridge

The forward steering position consists of two Electronic Chart Display and Information Systems (ECDIS); these are electronic systems that integrate real-time data from various information sources such as Global Positioning Systems (GPS) and Automatic Identification Systems (AIS). ECDIS includes navigational charts and displays sailing directions and the vessel's position relative to other objects such as other vessels. In practice, the bridge crew establish a passage plan in the electronic chart that is embedded in the ECDIS. Throughout the voyage, the system will provide alarms whenever the vessel deviates from the predefined route, for instance if the bridge crew fail to change course at a waypoint in the passage plan. The forward steering position also includes two radars, which use radio waves to measure the direction and distance of other objects. This system will provide alarms whenever the vessel is on a collision course with another object in the fairway. The forward steering position also consists of various indicators relative to the status of the technical system on board the vessel, such as thruster control, engine control and autopilot. When sailing between ports and the oil and gas fields, the forward steering position is used. Operations alongside the offshore facilities, however, are normally performed by means of a dynamic positioning (DP) system, located in the aft steering position. The DP is a system that keeps the vessel in a fixed position by means of reference systems such as GPS. The bridge crew's role in these situations is to programme the DP, monitor the system, diagnose errors and implement actions whenever needed. In addition, the aft steering position is equipped with communication facilities and computers for cargo control. The aft steering position is also equipped with manual controls that allow the bridge crew to manoeuvre the vessel manually, such as in cases of technical deficiencies or failure in the DP-system.

The ECDIS, radars, the DP-system and other indicators on the technical status of the vessel will provide important SA information in relation to the safe operation of the vessel. From this perspective, the bridge may be viewed as a complex collaborative system where SA relevant information is distributed between both humans and technological aids. It is thus essential that information is transferred to the person



who needs it in a timely and accurate manner. Failed or delayed transactions of SA relevant information from technological equipment to the bridge crew may be caused by factors such as the inattention of the bridge crew or inadequate presentation of information in technological equipment.

### **1.3.2 The crew**

The bridge organization on an offshore vessel is hierarchically organized and normally consists of four officers (i.e. the master, chief officer, first officer and second officer). The officers are organized in two shifts, and it is common that the chief officer and the master are paired with an officer of lower rank. Considering that the life on board a vessel is a 24-hour community, in which the bridge crew work in close cooperation with each other, it is a reasonable assumption that the master, as the highest-ranking leader on board the vessel, will have great influence on work performance.

According to international conventions (e.g. the International Convention for the Safety of Life at Sea<sup>1</sup>) and national regulations (e.g. Forskrift om vakthold på passasjer og lasteskip), two persons are required to be present on the bridge during the voyage. This may be two officers or one officer and one crew member with a bridge watch certificate. It is, however, sufficient to have one officer present on the bridge in daylight, given that other relevant factors such as weather conditions, visibility and traffic density do not represent a risk. In addition, one or two cadets may add to the bridge organization for training purposes.

In order to be able to carry out the operations in a safe and efficient manner, it is important that the bridge crew function well as a team. From a SA perspective, it is particularly important that the necessary information is available for each crew member to acquire sufficient SA to fulfil their role in the team. To do so, it is a

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<sup>1</sup> International Maritime Organization. (2012).

prerequisite that the bridge crew members share information with each other and communicate in an accurate manner.

Operations close to the offshore facilities are associated with risk. As a consequence, the offshore facilities are surrounded by a 500-metre safety zone, which vessels are not allowed to enter without permission from the offshore facility control room.

Whenever a vessel is operating inside the safety zones, the bridge is normally manned by two officers. In this way, there will be redundancy in the bridge organization, as the officers can provide support to each other. Even though redundancy in the bridge organization is supposed to increase safety, it is a prerequisite that the bridge officers have clarified their roles before they enter the safety zone – if that is not the case, the system may be vulnerable to human error caused by misunderstandings.

To reduce the risk of colliding with the offshore facilities, the bridge crew must pay particular attention to the planning phase prior to the operation. The bridge crew should also complete a checklist with regard to critical factors before they enter the safety zone. The items in the checklist will vary from shipping company to shipping company but will typically include establishment of communication lines with the offshore facility, assessment of weather conditions and specific checkpoints regarding the status of the technical system. If the bridge crew is going to conduct a dynamic positioning operation, it is further required that the bridge crew conducts a technical test of the system. In this way, the checklists will remind the bridge crew to pay attention to factors that are important in order to acquire the necessary SA for the operation.

### **1.3.3 The regulations**

The International Maritime Organization (IMO) has developed several international conventions aiming to improve safety at sea worldwide. For instance, the Safety of Life at Sea (SOLAS) specifies minimum standards for the equipment on board vessels. Of particular significance for the bridge crews' ability to achieve and maintain SA are that navigational systems and equipment should enable the bridge crew to have convenient and continuous access to essential information in a clear and

unambiguous manner (International Maritime Organization, 2012). Furthermore, following a series of major accidents at sea in the early 1990s, the International Maritime Organization developed regulations that account for human factors (Gholamreza & Wolff, 2008). For instance, the International Convention on Standards for Training, Certification and Watchkeeping for Seafarers (STCW) (International Maritime Organization, 2011) incorporated new minimum requirements for the training and competence of seafarers and thus aimed to increase the knowledge and skills of seafarers worldwide. From a SA perspective, these requirements are important since sufficient knowledge about the system is a prerequisite when it comes to the seafarers' ability to achieve and maintain SA. Furthermore, in 1993 IMO adopted the International Safety Management (ISM) Code (International Maritime Organization, 2010), which aimed to establish a minimum standard for safety management systems (Rodriguez & Campbell Hubbard, 1998-1999). The code requires that the shipping companies' safety management systems should include specific functions such as procedures and checklists for safety critical operations and a procedure that ensures that all personnel are properly familiarized with their duties. Within the framework of the code, the maritime industry is, however, free to design their safety management systems to their own needs. A recent example is the Guidelines for Offshore and Marine Operations (G-OMO)<sup>2</sup> (Guidelines for Offshore Marine Operations, 2013), the purpose of which was to incorporate the best practices within the industry. In that way, the guidelines serve as an industry standard for the safe operation of offshore vessels. Implemented on June 1st 2014, the G-OMO were developed as a joint project by maritime and offshore organizations in Denmark, the Netherlands, the UK and Norway.

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<sup>2</sup> G-OMO superseded the North West European Area (NWEA) Guidelines, which were implemented in June 2009.

## 1.4 Theoretical foundation

The following sections will outline the theoretical foundation for the thesis. There will be particular emphasis on theories of SA and leadership styles (i.e. authentic leadership and laissez-faire leadership).

### 1.4.1 Theories of SA

Situation awareness (SA) has always been critical in operational settings that involve risk. According to Gilson (1995), the concept of SA was first recognized by Oswald Boelke during World War I as “the importance of gaining an awareness of the enemy before the enemy gained similar awareness, and devised methods for accomplishing this” (p. 3). It was during the late 1980s, however, that the concept first became subject to increased interest as a research topic. The early seeds of interest arose as the technological developments in the aviation industry had changed the crews’ role from active doers towards being monitors of automated systems. The term ‘SA’ was then coined to describe how the crew perceived and processed large amounts of information in a dynamic environment (Endsley & Garland, 2000). Since then, various definitions of and approaches to SA have emerged. A primary distinction between definitions is whether they refer to SA as a product or a process. The distinction is made clear by Dominguez (1994), who argues that “The process of SA refers to how SA is developed and maintained (...), while the product is the resultant, elusive thing we call SA itself” (p.7). In other words, process refers to “perceptual and cognitive activities involved in revising the state of situational awareness whereas product refers to the state of situational awareness with regard to available knowledge” (Stanton, Chambers, & Piggott, 2001, p. 197). This thesis does not examine the product of SA itself but rather the working practices and other conditions on offshore vessels that are decisive in the process of achieving and maintaining SA. Hence, this work is supported by theories that emphasize the process of achieving and maintaining SA, rather than theories that solely emphasize the product of SA itself.

SA related research has gradually become comprehensive, but to date there are no agreements about the definitions and models of SA (Salmon et al., 2008). Lack of

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agreement regarding what SA is was most recently demonstrated in a special issue on SA in the *Journal of Cognitive Engineering and Decision Making* (2015, Volume 9, No. 1). The genesis of this special issue was an article by Mica Endsley (2015), which reviewed criticism of her model for SA. Her most prominent critics were invited to discuss her response to the criticism. In that way, this special issue provides an overview of the grounds on which the most prominent contributors to SA research disagree and agree.

According to Stanton et al. (2001), despite disagreements regarding how SA is defined, the literature may be divided into two main disciplines. The principal distinction between these disciplines is whether it can be best understood from a psychology or systems ergonomics perspective. From a psychology perspective, SA refers to cognitive processes in each individual mind. Hence, the unit of analysis is the operators within the system. From a systems ergonomics perspective, SA is viewed as a system property. Hence, the unit of analysis is the whole sociotechnical system. In the next sections, these two perspectives are further outlined.

#### **1.4.1.1     *The psychology approach to SA***

The psychology approach is by far the most dominant within the body of research on SA, and Mica Endsley's three-level model is the most cited one (Stanton, Salmon, Walker, & Jenkins, 2010). She defines SA as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1995, p. 36). The theory highlights SA as both a product and a process. However, the state of knowledge is defined as SA and the process of achieving and maintaining that knowledge is defined as *situation assessment* (Endsley, 1995). Although the model describes SA on three levels, time is central in the definition and highlights the dynamic aspects of situations. Along with time and changes in the situation, the operator's SA must change, to avoid becoming outdated and increasing the probability of human error (Endsley, 2000). Returning to the three levels in Endsley's model, the operator must perceive critical information that is relevant to his or her goals (SA Level 1). In the context of safe navigation, this information may include

the vessel's operational status, the vessel's positioning and other approaching vessels. The officers also need to integrate and evaluate the information at hand. They must understand the perceived information in relation to relevant goals, such as safe positioning alongside an offshore facility (SA Level 2). Finally, the officer must use his or her comprehension of the situation to forecast future status (SA Level 3). Although the definition highlights that SA should be understood relative to the operator's goal, it also highlights that it is necessary to switch between "data-driven (bottom-up) and goal-driven (top-down) processing" (Endsley, 2000, p. 13). In goal-driven processing, the officers' attention is directed towards information in the environment that is relevant in light of the officers' goals. In data-driven processing, the officer scans the environment for information that may indicate a need to switch goals. The switching between these two kinds of processing information in the environment is viewed as critical (Endsley, 1995).

As shown in Figure 3, SA is closely related to decision-making and performance in dynamic environments. In order to make good decisions, it is a prerequisite to have a well-developed SA (Endsley, 1995). For instance, information regarding the heading and speed of both one's own and nearby vessels and a subsequent calculation of the 'closest time to approach' (SA level 3) determines good decision-making (e.g. the decision to alter course).

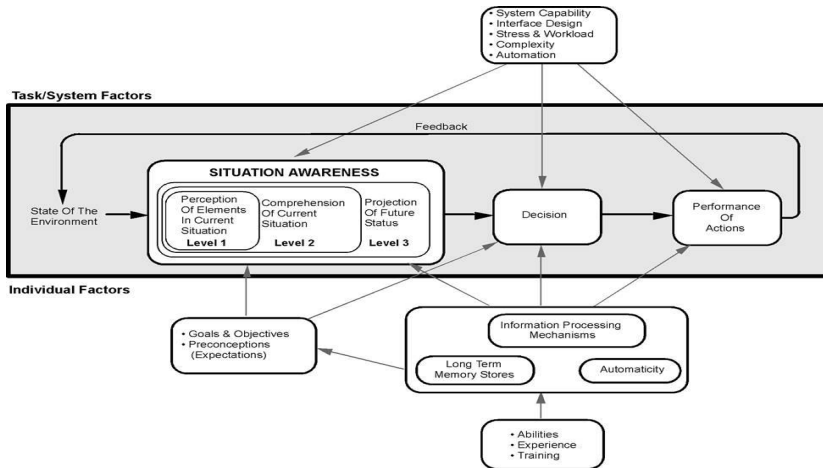


Figure 3: Model of situation awareness in dynamic decision-making (Endsley, 1995, p.35). Reprinted by permission of SAGE Publications, Inc.

Endsley's theory of SA has been criticized because it does not explicitly include the wider sociotechnical system (e.g. Salmon, Stanton, Walker, Jenkins, & Rafferty, 2010). The model does include, however, several factors, both on the task/system level and on individual level, which influence the operators' SA. This will be further outlined in Section 1.4.2.

Mica Endsley's theory also includes SA in teams, which is defined as "the degree to which every team member possesses the SA needed for his or her responsibilities" (Endsley, 1995, p. 39). From this perspective, it is acknowledged that operators within a given system have various roles and responsibilities and therefore need different SA to fulfil their role in the system. It is thus important that SA information is transferred to the person who needs it, so that he/she may achieve the SA necessary to fulfil his/her role in the system (Endsley, 2015). A related concept to team-SA is shared SA, which is defined as "the degree to which team members have the same SA on shared requirements" (Endsley & Jones, 2001, p. 48). The concept of shared SA refers to the fact that some SA requirements may be shared by team members, due to overlapping responsibilities (Endsley, 2015; Endsley, 1995). From this perspective, a great deal of coordination in teams involves sharing of information, including sharing of higher levels of SA (i.e. comprehension and projection) (Endsley, 1999).

Smith and Hancock (1994) have developed another approach within the tradition of psychology. In their theory, they refer to Neisser's (1976) "perceptual cycle", which suggests that information in the environment modifies our knowledge (schema<sup>3</sup>), our knowledge (schema) directs our search for information in the environment, our search for information leads to a gathering of information – which in turn leads to modification of knowledge (schema) and so on. In this way perception is a circular construct with no beginning and no end (Smith & Hancock, 1995). Following on from this, Smith and Hancock (1994) suggest that SA is an "adaptive externally directed consciousness towards a task environment" (p. 60). The term 'adaption' refers then to the match of our "knowledge, beliefs, and goals to the information and activity made available by the environment", while the term 'externally-directed' indicates that SA is "goal-driven behaviour" (Smith & Hancock, 1994, p. 60). In a maritime context, SA as an externally directed consciousness could be understood by the following example: an offshore vessel is in open waters heading towards port. A lighthouse may tell him/her that he/she is approaching coastal water, and the officer's schema will be modified. This will in turn direct the officer to explore risks associated with coastal water such as looking for islets and reefs. Depending on the result of the exploration, the schema may be modified or/and attention may be directed towards other aspects of the situation. Endsley (2012) also recognizes SA as a circular construct and argues that a person's SA will influence the kind of information we attend to. Smith and Hancock (1994) have added an element to Neisser's perceptual cycle. The 'invariant' symbolizes a link between the other elements in the model. In order to understand the 'invariant's' role, it is necessary to keep in mind the distinction between competence and performance. While performance is related to behaviour in a specific situation, competence is related to knowledge that is independent of a specific situation (Smith & Hancock, 1995). The

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<sup>3</sup> The concept of schemata was introduced for the first time by Bartlett in the 1930s. He defined schemata as various knowledge structures, located in our long-term memory. Similar to the concept of mental models (which are also located in our long-term memory), we use schemata to interpret and to predict what will happen next in the world. In this perspective, schemata are similar to mental models (Jones, Ross, Lynam, Perez, & Leitch, 2011). However, there have been some attempts to distinguish between the two concepts. For an overview, see Jones et al. (2011).



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authors then argue that the ‘invariant’ is competence in coding information in the environment or the knowledge that the operator needs to evaluate the information and the behaviour it directs. SA is thus recognized as an “invariant but adaptive component in a cycle of knowledge, action and information” (Smith & Hancock, 1994, p. 67).

#### ***1.4.1.2 The systems ergonomics approach to SA***

The psychology approach views SA as something that is situated in the minds of individuals. The systems ergonomics approach emphasizes interactions between people and the objects they use in day-to-day operations (Stanton et al., 2010). This approach is inspired by Hutchins’ (1995) theory of distributed cognition, which proposes that cognition is a system property rather than an individual property in collaborative systems. Artman and Garbis (1998) were the first to combine the theory of distributed cognition with SA. Stanton and colleagues (Stanton, Salmon, Walker, & Jenkins, 2009; Stanton et al., 2006) advanced this idea and have proposed a theory of distributed SA (DSA). The theory of DSA is distinguished from other approaches to SA by looking at the whole system as its unit of analysis rather than the operators within it. From this perspective, the physical objects are important holders of SA relevant information and should be included in an analysis of the systems’ SA. It does not matter whether an operator or a physical object holds the information, as long as the information is transferred to the person who needs it in due time (Stanton et al., 2010). In a maritime context, the bridge is a cognitive system, consisting of the bridge crew members and the physical objects that they use (e.g. various items of technical equipment, checklists, procedures). Following on from a DSA perspective, the bridge can only be understood by focusing on how each crew member and physical object contributes to the operation and how the work is coordinated in order to accomplish the goal.

Each operator’s SA is not redundant in a DSA perspective. Rather, the authors view each operator’s SA as equal to the state of their perceptual cycle, as proposed by Smith and Hancock (1994) (Salmon et al., 2010; Stanton et al., 2009). The notion of shared SA is rejected in a DSA perspective because each individual will have a

different view of a situation – even when the information input is identical (Stanton et al., 2009). The reason for this is that information within the environment will be linked to already existing information in each individual mind and produce unique schemas. Consequently, it will be impossible to achieve shared SA between team members (Stanton et al., 2010). The DSA perspective emphasizes, however, the importance of compatible SA in collaborative systems (Salmon, Stanton, Walker, & Jenkins, 2012). The idea entails each agent’s SA being compatible, in the sense that each agent has the necessary SA to realize her/his/its role in the system. Thus, on a team level, the notion of compatible SA is comparable with Endsley’s (1995) team SA concept, as they both highlight the fact that each team member should possess the SA necessary for his or her role in the system (although Endsley’s model does not include physical objects). The DSA approach may explain SA in bridge operations with the following example: for the vessel as a system to hold the necessary SA for the voyage, it is essential that each agent has the necessary SA for his or her role in the system (e.g. the lookout and the officer in command). Both the lookout and technological objects such as radars are important holders of SA information in relation to the officer in command’s role in the system (i.e. information about nearby vessels and other objects in the fairway). That is, the radar should be able to provide information on the subject, the officer in command should be able to understand and act upon that information, and the lookout should be able to transfer relevant information to the officer in command.

#### **1.4.1.3 *Pulling the threads together***

In the previous sections, I have presented two different approaches to SA: the psychology approach and the systems ergonomics approach. The psychology approach was represented by Mica Endsley’s (1995) three-level model, along with Smith and Hancock’s (1994; 1995) theory of SA as “adaptive externally directed consciousness”. Stanton, Salmon and co-workers (Stanton et al., 2009; Stanton et al., 2006) represented the systems ergonomics approach to SA. Throughout this review, it became evident that, despite the approaches being supported by different theoretical traditions, they coincide on some points. For instance, the DSA approach emphasizes that it is important for each agent (e.g. the officer) to have the necessary SA in

relation to his or her role in the system (compatible SA). This is to some extent in line with Mica Endsley's team SA concept, which highlights that each team member's SA should be in line with his or her role in the system. Furthermore, Smith and Hancock's theory of SA builds on Neisser's (1976) "perceptual cycle", which, from a DSA perspective, equals each individual operator's SA. When it comes to the 'perceptual cycle', this is to some extent in line with Endsley (2012), who argues that the current state of our SA will influence the kind of information we attend to. However, the theories differ regarding their unit of analysis. The three-level model focuses on cognitive processes in each individual mind; SA, as 'adaptive, externally directed consciousness', focuses on the interface between the operator and the environment, while, from a DSA perspective, the unit of analysis is the whole collaborative system. Table 1 summarizes how the theories relate to a selection of key elements.

Table 1: Summary of key elements in selected theories on SA

	<b>The three-level model</b>	<b>SA as adaptive externally directed consciousness</b>	<b>Distributed SA</b>
<b>SA in individuals</b>	The ability to perceive, comprehend and project future states.	Equals the state of the operator's perceptual cycle. Competence in coding information is central (the invariant).	Equals the state of the operator's perceptual cycle.
<b>SA in teams</b>	The degree to which each team member possesses the necessary SA relative to the role he or she has in the system.	Not included in the concept.	Not included in the concept, but each agent in a system should possess the SA necessary for his or her role in the system (compatible SA).
<b>SA as a system property</b>	Does not recognize SA as a system property, but emphasizes factors within the wider sociotechnical environment that influence the ability to achieve and maintain SA (e.g. design of technology).	Not included in the concept.	Views SA as a system property rather than an individual property.
<b>Shared SA</b>	The degree to which team members have the same SA on shared requirements.	Not included in the concept	Rejects the possibility of shared SA.
<b>Unit of analysis</b>	Cognitive processes in each individual mind.	Interactions with the environment.	The whole sociotechnical system.

For an overview of theories on SA, see Salmon et al. (2008), Stanton et al. (2001) and Wickens (2008).

### 1.4.2 Antecedents to SA

Knowledge regarding factors that influence the ability to achieve and maintain SA may improve safety in the maritime industry. From previous research, we have gained considerable knowledge about such factors. In the following, I present a summary of relevant themes.

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#### 1.4.2.1 *Technical factors*

The design of technology is an important factor when it comes to our ability to achieve and maintain SA in technology driven systems. In this respect, Endsley (see e.g. Endsley, 2001; 2012) suggests several design principles that intend to contribute to a SA-oriented design. In general, it is highlighted that “Presenting a ton of data will do no good unless it is successfully transmitted, absorbed and assimilated in a timely manner by the human to form situation awareness” (Endsley, 2001, p. 4). One of the design principles concerns co-locating information associated with a specific goal (Endsley, 2001; 2012). Co-location of information means that the bridge crew does not have to relate to several sources to find the information needed for a single goal. When it comes to the goal of avoiding collisions and groundings, the ECDIS may serve as a simple example. Latter versions of the ECDIS provide for the possibility to integrate information from the radar. In this way, it is possible to show important information that concerns the risk of colliding or grounding on one screen. It is further recommended that the system provide for direct presentation of higher levels of SA information (i.e. level 2 and level 3 SA) rather than a lower level of SA information. For instance, in the ECDIS the bridge crew has the possibility to compute a ‘sector’ ahead of the vessel. The ECDIS will thus use information about the sea depth within the sector and integrate it with information about the vessel’s draught (the depth below the water line to the bottom of the vessel’s hull). Whenever the bridge crew finds itself in a situation where there is a risk of grounding, an alarm will sound. In this way, the bridge crew does not have to integrate and interpret the lower level of SA information (i.e. sea depth and draught) manually, but, rather, the information will directly support the bridge crew’s higher levels of SA in relation to the risk of grounding. Another key principle in SA-oriented design is to filter information that is not related to SA needs and to make critical cues salient (Endsley, 2001)<sup>4</sup>. The technology aspect has been particularly highlighted in the engineering approach towards SA. The engineering approach emphasizes that SA is manifested in the physical world, represented by various aids and objects that people use to fulfil

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<sup>4</sup> For a more detailed description on SA-oriented design, see Endsley, 2012.

their goals (Stanton et al., 2010). The engineering approach is not rooted in a theoretical context; rather, the literature refers to cases where the practitioners themselves view SA as situated in technology. For instance, in one study, military helicopter pilots referred to information presented on the displays as their SA (Jenkins, Stanton, Salmon, Walker, & Young, 2008 as cited in Sorensen, Stanton, & Banks, 2011).

#### **1.4.2.2 Individual factors**

Our cognitive capacities influence our ability to achieve and maintain SA. For instance, our attention is finite and the amount of information that we can attend to is determined by our attention capacity (Endsley, 2012; 1995). When we integrate new information with existing information, we use our working memory to comprehend the meaning of the information. Working memory is our “temporary store of information that is rapidly forgotten if not rehearsed” (Wickens, 2002, p. 129). Our working memory has also limited capacity and may therefore exceed the requirements in dynamic environments. To overcome the limited capacity, however, we may use our mental models stored in the long-term memory (Endsley, 1999). More precisely, mental models may be defined as “mechanisms whereby humans are able to generate descriptions of system purpose and form, explanation of system functioning and observed system states and prediction of future states” (Rouse & Morris, 1986, p. 7). In practice, the use of mental models relies on our ability to identify key information in the environment, which in turn is mapped to key information in the mental model. The mental model may then provide for higher levels of SA such as generating probable scenarios (Level 3 SA) (Endsley, 1995). Following prior experience and mental models, a form of automaticity may occur, which “tends to be fast, autonomous, effortless, and unavailable to conscious awareness” (Endsley, 1995, p. 45). Automaticity requires minimal attention and may overcome some of the problems related to limited attention capacities. For instance, the officer may be aware of a certain problem in the technical system but unaware of the cues that led to that awareness (e.g. a specific sound) (Endsley, 1995).

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### 1.4.2.3 *Task factors*

Factors that are related to the way we conduct tasks (shipboard practices) and the total workload may influence our ability to achieve and maintain SA. As focused attention is a prerequisite (Endsley, 1995), we are vulnerable to distractions and interruptions (Endsley & Robertson, 2000; Flin, O'Connor, & Crichton, 2008; Robertson & Endsley, 1995). The management of interrupting and distracting elements is thus an important task from a SA perspective. Distracting and interrupting elements may stem from various sources such as incoming telephone calls, concurring tasks and informal conversations with other crew members, to mention a few. The risk associated with interruptions and distractions is acknowledged in the maritime industry. For instance, the guidelines for offshore marine operations (G-OMO) cite that "Each member of the bridge team should be able to concentrate on his primary responsibilities. Other activities should only be undertaken when they will not compromise such responsibilities" (Guidelines for Offshore Marine Operations, 2013, p. 62). Workload may also influence our ability to achieve and maintain SA (Endsley, 1995). For instance, in previous studies, workload that exceeds our capabilities has been found to be linked to negative work outcomes such as increased stress (Bakker & Demerouti, 2007; Karasek, 1979). A high amount of stress may in turn challenge the operator to maintain SA in several ways, including "attentional narrowing, reductions in information intake and reductions in working memory capacity" (Endsley, 1999, p. 265). High-quality planning prior to a task is in general important from a safety perspective. It may also reduce the risk of SA errors, as it can increase bridge teams' understanding of risk associated with a specific task (Flin et al., 2008). Studies also indicate that high-quality planning before performing a task promotes shared mental models in a team (Stout, Cannon-Bower, Salas, & Milanovich, 1999). Anticipating possible scenarios and threats in the planning phase of a task is believed to be particularly important (Endsley & Robertson, 2000; Shook, Bandiero, Coello, Garland, & Endsley, 2000). Furthermore, communication between team members is critical in operational settings and may prevent misunderstandings and loss of SA (Flin et al., 2008; Kanki, 2010; Weick, Sutcliffe, & Obstfeld, 1999). In order to understand how practices regarding these matters can affect bridge crews'

information needs, it may be useful to distinguish between information exchange and communication. Information exchange refers to the kind of information transferred among the bridge team members, such as the location of other nearby vessels and the transfer of command during shift handover. In contrast, communication refers to the quality of the information exchange. One ideal that has been identified is to use brief and accurate terminology and to stay on task during the execution of navigation (Smith-Jentsch, Johnston, & Payne, 1998). In addition, actively checking that the information is correctly understood is important. Closed-loop communication is an effective technique for achieving this (Bowers, Jentsch, Salas, & Braun, 1998).

### **1.4.3 Previous research on SA in the maritime industry**

Research on SA within the maritime context is sparse. A search in psycINFO and Web of Science using the search string: (“situation\* awareness” OR “situation assessment”) AND (“maritime” OR “nautic\*” OR “sea” OR “ship” OR “ocean” OR “in bridge operation\*” OR “on board vessel\*”) generated respectively 45 hits in psycINFO and 91 hits in Web of Science. Many of these articles were not relevant, as they were duplicates or SA was not the main focus. Moreover, some articles were related to vessel traffic services, maritime security, unmanned water surface vehicles and aquaculture. Thus, in the review of previous research on SA, the inclusion criteria were research articles that had SA as the main theoretical concept and were conducted on the bridge within either a merchant or a military setting. Below, the six articles that meets the inclusion criteria is presented.

A study performed by Grech and colleagues (Grech et al., 2002) found that human error caused by loss of SA in the maritime industry is common. The study revealed that 71% of human errors in 177 maritime accidents were caused by loss of SA. Loss of level 1 SA was applicable in 58.5% of the cases. Loss of level 2 SA was applicable in 32.7%, while 8.8% was related to loss of level 3 SA. Research with more theoretical relevance has also been conducted within the context of the maritime industry. For instance, by means of a critical incidents technique, Øvergård and colleagues (Øvergård, Sorensen, Nazir, & Martinsen, 2015) collected information



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about 24 incidents that involved DP-systems. In their analysis of critical incidents on board vessels, the authors found that in some cases the operators were able to predict the outcome of an event (Level 3 SA), although their lower levels of SA were flawed. The authors thus suggest that SA does not have to be sequential but, rather, “adaptive and related to the work systems higher level goals” (p. 383). In that way, the operator may achieve higher levels of SA, independent of lower levels of SA. Further, when it comes to SA and decision-making, Chauvin and colleagues (Chauvin, Clostermann, & Hoc, 2008) found that correct perception of relevant SA elements (level 1 SA) was of secondary importance, relative to the decisions that were made. Rather, anticipation of the other vessels’ intentions and interpretation of the rules or what was considered as common practice was determinative for the decision-making. A simulator study conducted at a Naval Academy examined the relationship between personality traits and SA. The results from the study showed that participants who scored low on neuroticism and high on both conscientiousness and extraversion (measured by the NEO Personality Inventory) benefited the most from SA training (Saus, Johnsen, Eid, & Thayer, 2012). Moreover, Koester (2003) examined bridge crew communication in eight voyages on board two different ferries. The underlying assumption for the study was that, although SA is difficult to measure with the available methods, it is possible to observe changes in crew behaviour and communication, which in turn may give valuable *indications* about SA. Based on an analysis of communication on the bridge, the study provides examples of communication patterns that indicate that the bridge crews are proactive in the time before a major planned change in the situation, such as arrival in port. Finally, in a recent study from the petro-maritime industry, Sætrevik and Hystad (2017) examined how the authentic leadership of masters and SA combine and influence the seafarers’ risk assessment and unsafe actions. The study consists of survey data from 63 offshore vessels on hire to a major oil company. They found that an increase in the bridge crews’ SA was associated with a decrease in risk assessment and unsafe actions. An increase in the authentic leadership of masters was associated with a decrease in unsafe action and SA.

As shown above, research on SA in a maritime context is relatively sparse. In this respect, the present thesis is important and contributes to our understanding of how loss of SA has materialized in previous incidents at sea. In addition, the present thesis contributes with knowledge regarding factors that may affect the seafarers' SA in day-to-day operations on the bridge.

#### **1.4.4 Leadership styles**

This thesis has aimed to examine how authentic leadership and laissez-faire leadership in masters may influence SA in day-to-day operations. In the following, the concept of authentic leadership and laissez-faire leadership will be further outlined.

##### **1.4.4.1 *Authentic leadership***

According to Ford and Harding (2011), Bernard M. Bass was the first to introduce the term 'authentic leadership' in his theory of 'transformational leadership'. He included the concept of 'authentic leadership' in his original theory as an answer to critics, who pointed at the possibility for "narcissistic and authoritarian managers to masquerade as transformational leaders" (Ford & Harding, 2011, p. 464). Bass and Steidlmeier (Bass & Steidlmeier, 1999) argue that "Authentic transformational leadership must rest on a moral foundation of legitimate values" (p. 184). Following Bernard M. Bass's introduction of 'authentic leadership', several authors have developed the concept. However, in Article III, we relied on Avolio and Gardner's (2005) theory on authentic leadership, which suggests that authentic leadership is composed of the four components: self-awareness, relational transparency, balanced processing and internalized moral perspective. Self-awareness refers to an awareness of how the leader makes meaning of the world and how this meaning influences the way the leader views himself/herself. Relational transparency concerns presenting an individual's true self to others, such as openly sharing information and honestly expressing one's thoughts and feelings. Balanced processing refers to leaders, who objectively consider all relevant data before they reach a decision. Authentic leaders also encourage workers to express viewpoints that challenge the leader's own

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position. Finally, the internalized moral perspective refers to the fact that authentic leaders are guided by their own moral standards in their decision-making and behaviour. Instead of complying with the expectations of others, authentic leaders hold their own positions (Shamir & Eilam, 2005). They are also aware that their behaviour and decisions will send important signals to others and thus influence worker behaviour, which means that authentic leaders can serve as positive behavioural models (Avolio, Gardner, Walumbwa, Luthans, & May, 2004; Ilies, Morgeson, & Nahrgang, 2005). In a study from the maritime industry, Borgersen, Hystad, Larsson and Eid (2013) found that authentic leadership by masters was positively related to crew perceptions of safety. This is in accordance with a study from the oil and gas industry, where Nielsen Birkeland, Eid, Mearns and Larsson (2013) demonstrated a positive relationship between authentic leadership and safety climate. These authors also found that authentic leadership was negatively related to workers' risk perception. Overall, the accumulated data suggest that authentic leadership has a positive effect on safety-related outcomes. The importance of a safety-oriented shipboard management is also highlighted in other studies (Håvold, 2010; Hetherington, Flin, & Mearns, 2006; Oltedal & Wadsworth, 2010; Oltedal & Engen, 2009).

Theories on authentic leadership have not been introduced without controversy. For instance, Wetzel (2015) argues that the idea of a "stable core self" in the sense that it can be recognized and explained to both ourselves and others is a myth (p. 41), and a leader will therefore always fail in his search for his/her true self. Ford and Harding (2011) also discuss the notion of a 'true self' and argue that theories of authentic leadership "refuse to acknowledge the rounded subject as someone full of contradictions" (p. 476). Wetzel (2015) further argues that a leader does not hold an unambiguous role in relation to the organization. Rather, the leader will face contradiction in expectations and demands that will influence the leader's behaviour. In other words, both the leaders and the organization lack a stable core – whereupon authenticity will be impossible. This argument is supported by a study conducted by Nyberg and Sveningsson (2014), who found that leaders reported to have restrained their authenticity in order to be perceived as good leaders. According to the authors, it

is thus misleading to examine leadership disconnected from the context in which the leadership takes place.

#### **1.4.4.2 *Laissez-faire leadership***

According to Bass (1997), laissez-faire leaders “avoid accepting their responsibilities, are absent when needed, fail to follow up requests for assistance, and resist expressing their views on important issues” (p. 134). In other words, laissez-faire leadership may be seen as lack of leadership. Surprisingly, few studies have examined the effect of laissez-faire leadership on safety related outcomes, as opposed to studies concerning leadership that is more active. However, Kelloway, Mullen, & Francis (2006) found that passive and active leadership should be viewed as distinct constructs in a sample of part-time workers. These authors argued that active and passive leadership should be considered as distinct constructs rather than opposite ends of the same continuum. Zohar (2002) conducted a study that focused on the effect of laissez-faire leadership on safety climate. Not surprisingly, this study found that laissez-faire leadership was negatively related to the group-level safety climate. Laissez-faire leadership has also been shown to be associated with other workplace variables such as worker job satisfaction (Judge & Piccolo, 2004), motivation (Chaudhry & Javed, 2012), role conflicts, role ambiguity and conflicts with co-workers (Skogstad, Einarsen, Torsheim, Aasland, & Hetland, 2007). These studies lend support to Skogstad and colleagues' (Skogstad et al., 2007) argument that laissez-faire leadership should be viewed as a destructive form of leadership rather than a type of zero leadership.

## 2 Research questions

The previous sections have presented the research aims and theoretical foundation for the thesis. The overall research problem guiding the presentation was:

*How may shipboard factors influence the ability to achieve and maintain SA in day-to-day operations on offshore vessels?*

In order to shed light on the research problem, the following research questions have been developed:

1. How may shipboard factors have influenced loss of SA in previous incidents at sea? (Article I)
2. How may shipboard practices affect transactions of SA related information on board offshore vessels? (Article II)
3. How may on-board leadership affect the ability to achieve and maintain SA on board offshore vessels? (Article III)

## **3 Methodology**

In the initial phase of this thesis, several preparatory activities were carried out in order to gain system knowledge about the maritime industry: (1) a field trip, lasting for one week, on board a platform supply vessel, (2) a field trip to a traffic surveillance centre, (3) simulator activities, and (4) informal conversations with seafarers. System knowledge derived from these types of activities is considered a prerequisite for conducting research within a specific area (Neuman, 2006).

In the following sections, I describe the methodology that applies to each of the three studies in the thesis. Methodological considerations are accounted for in Section 6.2.

### **3.1 Study one**

Study 1 is an analysis of accident reports concerning collisions between offshore vessels and offshore facilities on the Norwegian continental shelf in the period 2001-2011. Collisions between offshore vessels and offshore facilities were selected as study objects due to the potential catastrophic outcome, inherent in these types of incidents. In addition, offshore-related maritime operations involve interaction between several actors, such as the offshore facilities. In that way, the complexity of the organization adds a unique aspect to the cases, compared to other incidents within the maritime industry.

#### **3.1.1 Data collection**

Accident reports were retrieved from various organizations, including the Norwegian Maritime Authority, the Norwegian Petroleum Authority, a shipping company and an oil company. Reports were collected from 24 of a total of 28 incidents in the selected period, but one collision was excluded from the sample due to sparse information in the accident report. Three of the incidents were investigated by more than one agency or organization, resulting in a total of 28 accident reports. Thus, 28 accident reports concerning 23 collisions were included in the study. The accident reports were prepared by various organizations. Ten reports originated from operators, 14 from

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shipping companies, two from consulting firms in cooperation with shipping companies, one from the owner of an offshore facility and one from the Norwegian Petroleum Safety Authority.

### 3.1.2 Data analysis

Initially, the aim of the study was to examine contributing causes to the collisions in general terms. To this end, several methods were considered before the final decision was made. An example of a strategy that was rejected is the Human Factors Analysis and Classification System (HFACS). HFACS is a classification scheme that allows classification of unsafe acts and preconditions for unsafe acts (Wiegmann & Shappell, 2003). HFACS turned out to be inappropriate with regard to the cases in question, due to the type of information that was available in the accident reports.

The final decision regarding analyses of the accident reports followed a three-step process. The first step was *open coding* followed by *axial coding* (Neuman, 2006). By means of *open coding*, each section in the accident report that described a cause of the collision was assigned an initial code. The open coding was followed by axial coding, where initial codes were compared across the cases. The objective of the axial coding was to look for similarities between different codes and to collapse codes into broader categories. The results from the axial coding indicated that failures related to “problem detecting” and failures related to “problem diagnosis” were two categories that occurred frequently in the sample. The categories derived from the axial coding were then compared with theoretical concepts in the literature, whereof “problem detection” and “problem diagnosis” were considered to correspond with the two first levels in Mica Endsley’s (1995) three-level model of SA. In the second step, the accident reports that involved some sort of human error were re-examined and analysed, according to Jones and Endsley’s (1996) taxonomy that allows for classifications of accidents in accordance with Endsley’s three-level model. Finally, in order to provide a greater understanding of how human, technological and organizational factors may have contributed to the loss of SA, factors that may have influenced the bridge crews’ SA in the course of events were

identified. The coding of influencing factors followed a process of open and axial coding, as described above.

## 3.2 Study two

Study 1 identified inter alia planning failure, communication failure and interrupting/distracting elements as factors influencing the loss of SA in the course of events. Study 2 draws on these findings and examines how shipboard practices related to these matters play out in day-to-day operations on board offshore vessels. The methodological approach to Study 2 is field studies, and the theoretical foundation is DSA, which allowed for examination of shipboard practices in order to describe how SA information is distributed and coordinated on the bridge.

### 3.2.1 Data collection

The fieldwork was conducted on board four different platform supply vessels, which belong to two Norwegian-controlled shipping companies. Platform supply vessels were selected as study objects because these vessels frequently approach offshore facilities, as well as being the most common vessel type involved in the cases included in Study 1. A total of 18 bridge crew members (15 officers and three cadets) from eight shifts participated in the study. The fieldwork was conducted in the period October 2012 to October 2013. Each observation period lasted between 8 and 14 days, with an average attendance on the bridge of approximately 10 hours a day.

Several have suggested that writing field notes in view of the participants may influence the relationship between the researcher and the participants (Emerson, Fretz, & Shaw, 1995; Fangen, 2005). Field notes were therefore written in retrospect when I was out of sight of the bridge crew. I therefore withdrew to my cabin several times a day, or immediately after a significant event, to write down observations and quotes in a fieldwork diary. During the fieldwork, no form of video or audio recordings was utilized. The reader should therefore be aware that observations and quotations that are presented in this thesis are as remembered in retrospect by the researcher.



The themes for the fieldwork were planning, communication and management of distracting/interrupting elements. These themes refer to interactions among agents in the system and thereby connect to DSA. However, in order to focus on situations relevant to the PSV setting, the study required more accurate concepts. In the process of developing such concepts, we drew on findings from Study 1 along with previous studies of collisions between offshore vessels and offshore facilities (Kvitrud, 2011; Oltedal, 2012), information derived from a preparatory field trip on board a platform supply vessel and informal conversations with experienced navigators. Concepts were then selected based on previous research and the informed opinions of navigators. Together, these concepts served as a framework that gave the study direction. The framework is provided in Table 2.

Table 2: Framework that gave the study direction

<b>Themes</b>	<b>Observable practices</b>
Planning	Planning of approach towards the offshore facility
	Contingency planning during operations
Communication	During completion of checklists
	During transfer of command
	During transfer of manoeuvring position
Distractions and interruptions	Caused by administrative tasks
	Caused by electronic devices
	Caused by non-essential conversations

During the fieldwork, I adopted a role in line with Gold's (1958) "participant-as-observer". That is, I observed and interacted with the bridge crew in their day-to-day activities. This involved taking part in conversations and asking questions when the bridge crew members were available. The bridge crew also demonstrated how some of the equipment on the bridge worked, thereby providing the opportunity to

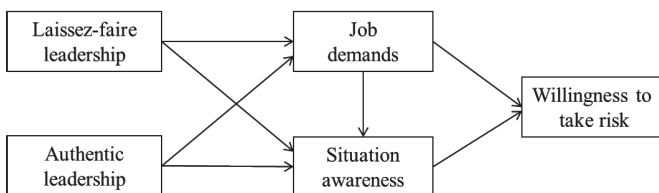
elaborate on technical information that emerged during conversations and observations.

### 3.2.2 Data analysis

Initially, observations and quotes were systematized, according to the concepts included in the framework. We thereby used a “provisional coding” method, where codes were generated from investigations carried out prior to the fieldwork (Saldaña, 2009). The representational style can be classified as a “realist tale”, according to John Van Maanen’s (2011) classification (p. 45). That is, the results are presented as concrete descriptions of what the bridge crew do and say, organized according to the framework in Table 2 and finally discussed according to the theoretical concept of DSA.

### 3.3 Study three

Study 3 is independent of the findings in the two previous studies but is thematically related to them, as we examined factors that influence the ability to achieve and maintain SA in day-to-day operations. The study is based on survey data from offshore vessels; it tests a theoretical model on how the leadership style of masters may combine with psychological job demands and influence SA and risk-taking behaviour (see Figure 4). The reason for conducting the study was that Study 1 did not reveal the role of on-board leadership in the course of events leading to the collisions. As a result, we decided to design a study that included the effect of the master’s leadership style on the bridge crew’s SA.



*Figure 4: Theoretical model showing hypothesized relationships among the willingness to take a risk, situation awareness, psychological job demands, authentic leadership and laissez-faire leadership.*

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In addition to examining how leadership factors and psychological job demands influence SA, Study 3 examined the relationship between SA and behaviour (i.e. risk-taking behaviour). The study was conducted in a Norwegian-controlled shipping company that controls a large fleet of various types of offshore vessels. The theoretical model was tested in both the deck department and the engine department.

### **3.3.1 Data collection**

Questionnaires were sent out to 926 crew members on board 22 vessels. In total, 402 questionnaires were returned, yielding a response rate of 43.4%. Since the study concerned participants working in either the deck or the engine department, questionnaires from respondents working in the galley department were excluded, leaving an eligible research sample of  $N = 281$  ( $n = 178$  in the deck department and  $n = 103$  in the engine department).

Ten different nationalities were represented in the engine sub-sample. Norwegians constituted the largest group (31.1%), followed by Filipinos (30.1%) and Polish employees (25.2%). Permanent employees accounted for 52.4% of the sample, whereas 36.9% were on temporary contracts and 9.7% were apprentices (1% missing responses). The mean length of the seafaring career was 14.3 years, and the mean length of employment with the shipping company was 3.3 years. Ten different nationalities were also represented in the deck sub-sample. Norwegians constituted the largest group (50.6%), followed by Filipinos (29.2%); overall, 65.2% were permanent employees, 29.2% were on temporary contracts and 3.4% were apprentices (2.2% missing responses). The mean length of the respondents' seafaring career was 14.6 years, and the mean length of employment with the shipping company was 3.8 years. Thus, there were only minor differences in demographic variables between the two samples.

### **3.3.2 Measures**

Authentic leadership was measured by the Authentic Leadership Questionnaire (Gardner, Cogliser, Davis, & Dickens, 2011), which includes 16 items, where the

respondents were asked to rate the behaviour of the master using five response categories (1 = not at all; 5 = often, nearly always). The questionnaire measures the four components of authentic leadership: Self-Awareness (e.g., “Seeks feedback to improve interactions with others”), Relational Transparency (e.g., “Is willing to admit mistakes when they are made”), Balanced Processing (e.g., “Solicits views that challenge his or her deeply held positions”) and Internalized Moral Perspective (e.g., “Demonstrates beliefs that are consistent with actions”). Since it is the four components, as described above, that compose authentic leadership (Avolio & Gardner, 2005), only a total mean authentic leadership score was computed for the present study (Cronbach’s  $\alpha = .94$ ).

Laissez-faire leadership was measured by the Multifactor Leadership Questionnaire (Avolio & Bass, 2004). The respondents were asked to rate the behaviour of the master on five items with response categories, ranging from 1 (not at all) to 5 (very often or always). Examples of items included: “has avoided telling me how to perform my job” and “has steered away from showing concern about results”. Three items that are negatively scored were reversed before creating a total mean laissez-faire leadership score. Cronbach’s  $\alpha$  in the present study was .71.

Psychological job demands were measured by four items drawn from the General Nordic Questionnaire for psychological and social factors at work (Dallner, 2000). The items were rated on a five-point scale, ranging from 1 (seldom or never) to 5 (very often or always). These items measure the degree to which the work environment places demands on the individual in terms of time pressure and work load, through questions such as: “Is your work load irregular so that work piles up?” and “Do you have too much to do?” Cronbach’s  $\alpha$  in the present study was .71.

To measure the seafarers’ SA, they were asked to rate themselves on a context-general situation awareness scale (Sætrevik, 2013). The questionnaire consists of 13 items that are scored on a five-point scale, ranging from 1 (completely disagree) to 5 (completely agree). This instrument measures SA, according to the three levels from Endsley’s (1995) theoretical model. Four of the items reflect Level 1 (e.g., “I

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sometimes lose track of safety due to receiving too much information at the same time”), five of the items reflect Level 2 (e.g., “I know which situations in my work involve higher risk than others”), and finally, four items reflect Level 3 (e.g., “I plan ahead in order to handle various adverse incidents that may arise”). Five items that were negatively scored were reversed before creating a total mean SA score. Cronbach’s  $\alpha$  in the present study was .78.

Willingness to take risks on the job was measured by seven items that were adapted from a review of the relevant literature (Nielsen et al., 2013). The participants were required to respond to items such as “I have been in situations where I exposed myself to danger to get the work done” and “To get the job done, I sometimes ‘cut corners’ with regard to safety” on a five-point response scale, ranging from 1 (very seldom, or never) to 5 (very often, or always). Cronbach’s  $\alpha$  in the present study was .73.

### **3.3.3 Data analysis**

To test hypotheses, we performed path-analyses with a maximum likelihood estimation using Stata version 13.1. All analyses were conducted separately for the deck and machine sub-samples. In addition, we used a generalization of the Huber/White/sandwich estimator (Rogers, 1994; Williams, 2000) that relaxes the assumptions of normality in the errors and is also robust to heteroskedasticity. This estimator also relaxes the usual requirement of the observations being independent (i.e., independence of errors) and replaces it with the assumption of independence between clusters. In other words, the observations are assumed to be independent across the 22 ships included in our study but not necessarily within ships. Model fit was judged by examining the magnitude and statistical significance of path loadings, the variance explained and the standardized root mean squared residual (SRMR). The coefficient of determination (CD) and the SRMR are the only goodness-of-fit statistics that Stata provides when the Huber/White/sandwich estimator is used.

### 3.4 Research quality

In the three studies that are included in this thesis, we have applied both qualitative and quantitative methods. Study 1 is a documentary study. In Study 2, we used fieldwork as a methodological approach, while Study 3 is an analysis of survey data. In this respect, Lincoln and Guba (1985) have argued that, for quality, qualitative and quantitative studies need diverse evaluation criteria. Traditionally, the evaluation criterion of surveys has been validity, reliability and objectivity. According to Lincoln and Guba (1985), evaluation of research quality in a naturalistic enquiry such as fieldwork should focus on the trustworthiness of the study, including credibility, transferability, dependability and confirmability. Further, according to Scott (1990), the quality criteria in documentary studies, such as accident reports, should be authenticity, credibility, representativeness and meaning. In the following sections, I will describe how these quality criteria apply to the respective studies in the thesis.

#### 3.4.1 Study one

Scott (1990) has suggested authenticity, credibility, representativeness and meaning as quality criteria for documentary research.

*Authenticity* refers then to the truthfulness of the document – whether the document is genuine and not a forgery. When it comes to the accident reports included in Study 1, there are reasons to believe that they describe an actual event that has been investigated by designated investigators.

*Credibility* refers to whether the document is free from errors and falsification. According to Scott (1990), the accuracy of any document can never be known with certainty, but it is important to identify conditions that might have led to inaccuracy. In general, there are two potential sources of bias in the content of an accident report. Firstly, the informants may give an untruthful description of the actual course of events. Reasons for this can be that they do not remember exactly what happened, or they are not telling the truth because they fear reprisals or want to “save face”. Secondly, the investigators themselves may represent a bias through the “What-You-

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Look-For-Is-What-You-Find” principle (Lundberg, Rollenhagen, & Hollnagel, 2009). That is, the methodology that the investigators apply in the investigation will direct which aspects of the accident are paid attention to and which are ignored. However, in the majority of the cases included in Study 1, it is uncertain what kind of methodology the investigators have applied. It is therefore difficult to judge what kind of information was attended to and what kind of information was ignored. This in turn entails certain challenges when judging the credibility of the reports. This is not unique, however, for the reports included in this study but applies to accident reports in general, as they represent a subjective and selective version of the course of events (Reason, 2008).

*Representativeness* refers to whether the document is typical of its kind (Scott, 1990). In cases where the document is judged as untypical, the researcher needs to know in which way it is untypical in order to say something about the limitations in relation to the conclusions drawn. The sample in this study consists of available accident reports concerning collisions between offshore vessels and offshore facilities on the Norwegian continental shelf from the period 2001-2011. This period was chosen because the industry implemented a range of mitigating actions around 2000. Hence, there are reasons to believe that collisions that happened before 2001 would have a somewhat different causal picture. Each accident is, however, unique and the industry has a constant focus on improving safety on board the vessels. The conclusions drawn from the findings in Study 1 are thus not necessarily applicable for collisions that have happened since 2011 either.

*Meaning* refers to whether the content in the documents is clear and understandable (Scott, 1990). This matter relates to both the reader and the content of the reports. When it comes to the reader, we had some challenges in understanding the course of events in some of the reports, which was mainly a consequence of lack of nautical experience. To overcome this barrier, we discussed the reports with experienced navigators, who then explained the course of events. In addition, in some reports the investigators described some of the contributing causes to the collisions as means of

concepts, such as ‘poor seamanship’ and ‘lack of safety culture’. These concepts are ambiguous and it is thus difficult to understand how they relate to the causal picture.

In addition to the assessment of Scott’s (1990) quality criteria in documentary research, we examined the inter-rater reliability in the coding of accident reports, according to Jones and Endsley’s (1996) conceptual framework. The reports were independently analysed and classified by two of the authors. The results showed that we agreed in the majority of cases. In all but two cases, we reached agreement by clarifying and explaining our positions. In the remaining two cases, a third person analysed and classified the accident reports. The final classifications were in accordance with the classifications of the majority. In addition, in Article I we provide rich descriptions of the course of events, which in turn increases the transparency of the coding.

### **3.4.2 Study two**

Lincoln and Guba (1985) suggest four quality indicators for naturalistic inquiry: credibility, transferability, dependability, and confirmability.

When it comes to the *credibility* of Study 2, several techniques described by Lincoln and Guba (1985) are relevant. *Prolonged engagement* and *persistent observation* are techniques that refer to the importance of spending enough time in the field in order to build trust with the informants, to learn about the shipboard culture, to be able to test for misinformation, and to become sufficiently involved. In this particular study, the observation periods lasted between 8 and 14 days, with an average attendance on the bridge of approximately 10 hours a day. It is difficult to know with certainty, however, whether trust was established with the bridge crews – it may be assumed that the level of trust varied from officer to officer. Further, the technique *peer debriefing* refers to external checks by a disinterested peer. Throughout the whole study, I frequently discussed my preliminary findings with my colleagues, including other PhD students that had experience and knowledge of fieldwork. These discussions gave valuable input to the research process. Finally, *member checking* is a technique that refers to data, categories, interpretations and conclusions being



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tested/checked by persons that have first-hand knowledge and experience from the field. In this respect, preliminary findings and interpretations were frequently discussed with practitioners within the maritime industry.

*Transferability* refers to whether the findings of the study could be transferred to a similar context or, alternatively, to the same context, if the study was repeated at another time. Lincoln and Guba (1985) argue that it is impossible for a naturalistic researcher to deliver precise statements about external validity in comparison to quantitative research. The naturalistic researcher can only provide working hypotheses, along with tick descriptions about the context and the time of the study. The authors state that “Whether they [the findings] hold in some other context, or even in the same context at some other time, is an empirical issue, the resolution of which depends upon the degree of similarity between sending and receiving (or earlier and later) contexts” (Lincoln and Guba, 1985, p. 316). Through tick descriptions of the context, it is thus the researchers’ responsibility to make “transferability judgements” (p. 316) possible. In this study, we have emphasized detailed descriptions of the context by providing a sketch of a typical bridge, a description of relevant regulations and descriptions of the shipboard organization. In addition, we have provided rich descriptions of observations and statements from the officers. We believe that these descriptions may help the reader to make transferability judgements.

*Dependability* refers to whether the findings show stability over time and across researchers. Lincoln and Guba (1985) suggest several techniques to ensure dependability. In this study, we applied what they labelled an *inquiry audit*, which is a form of external examination of the research process leading to the findings and the conclusion. As previously mentioned, the research process was frequently discussed with colleagues and with the co-authors for the article. The research process was also described in detail in the article: that is, a description of the framework that guided the study, a description of the methodology, the presentation of findings and a description of how the findings led to the conclusion. The article was then presented

to reviewers in a journal and other members of the academic community, which in turn ensured external examination.

*Confirmability* refers to whether the findings are affected by researcher bias: that is, whether the informants' behaviour is influenced by the researcher's presence or the findings are influenced by the researcher's pre-understanding and/or prejudices (Lincoln and Guba, 1985). Pre-understanding of the research field is in general seen as a prerequisite for understanding and sense-making in fieldwork (Fangen, 2005; Gadamer, 2004; Grenness, 2001; Neuman, 2006). Some researchers, however, have highlighted that pre-understanding may lead to subjectivity and, in that way, affect the outcome of the study (Guneriusen, 1996; Paulgaard, 1997). From the perspective of Study 2, my pre-understanding originated from various sources such as previous research, informal conversations with seafarers and findings from Study 1. Schwartz and Schwartz (1955) argue that both the fieldworker and the informants create a context that would have been different if the fieldworker was different or not present at all. In that way, it is possible that the bridge crews would have behaved differently without my presence. This made me reflect on the 'pitfall' imbedded in my pre-understanding of the field and on my own influence on the bridge crew. However, spending a relatively long time on board the vessels may counteract some of the pitfalls associated with conformability in social sciences. In this respect, it has been argued that the informants will have difficulty in producing information that uniformly supports the researcher's pre-understanding, just as it will be difficult for the researcher to only see the things that support prejudice and pre-understanding (Fangen, 2005).

### **3.4.3 Study three**

Apart from authentic leadership, the Cronbach's alphas in this study were all in the lower region of what is generally considered 'acceptable' (i.e., .70). Although Cronbach's alpha is the most widely known and reported indicator of a test's reliability, it is also considered a lower bound to reliability and known to give severe underestimates in many cases (Sijtsma, 2009). Cronbach's alpha should therefore be

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regarded as a conservative estimate of reliability. Moreover, it also depends on the number of items in a test (Nunnally, 1978), with more items generally equalling higher alpha estimates. With the exception of situation awareness, the scales with relatively low alphas in this study all contain few items (between four to seven items). Finally, the alphas obtained in this study are comparable with alphas reported in the existing literature (e.g., Sætrevik (2013) for situation awareness; Wännström, Peterson, Åsberg, Nygren, and Gustavsson (2009) for job demands; Nielsen (2013) for laissez-faire leadership).

Ideally, the response rate from the survey (43.4%) should have been higher. However, compared to other studies conducted within organizational research, the response rate is considered acceptable (Baruch & Holtom, 2008). Furthermore, in the survey the seafarers were asked to rate their master according to the items on both the authentic and the laissez-faire leadership scales. Ideally, the personnel in the engine department should have been asked to rate the chief engineer, since they largely relate to him/her as the nearest leader. Hence, although the master is unquestionably the supreme leader on board the vessels, it is a reasonable assumption that the master's leadership style influences the personnel in the engine department to a lesser extent. Furthermore, the items in the 'risk-taking behaviour' scale were adapted from a review of relevant literature and not validated according to normal practices.

### 3.5 Ethical considerations

All three studies included in this thesis were independently reviewed and approved by the Norwegian Social Science Data Service. The studies were conducted in accordance with the preconditions for approval. However, some ethical considerations are outlined and discussed below.

The guidelines for research ethics in the social sciences, law and the humanities (2006) emphasize the principle of informed consent and the participants' rights to withdraw from the study at any time. In accordance with this, the seafarers received information about the project, including the right to withdraw from the project at any

time. It is easy, however, to imagine situations where it may be difficult for the seafarers to refuse to participate. For instance, in Study 2, the initial request regarding access was communicated to the seafarers via the shipping company's onshore organization. Since the seafarers on board the vessels are in an employment relationship, they may be less reluctant to refrain from participation when the request comes from a leader compared to an unknown researcher. Consequently, it is difficult to know with certainty whether the willingness to participate is based on 'true' consent or whether the participants recognize participation as part of their job. It is important, however, for the researcher to be aware of this possibility and to be sensitive to this issue during fieldwork. However, none of the participants in Study 2 expressed the view that they had doubts related to participation.

As mentioned in Section 3.2, a framework that consisted of predefined themes and observable practices initially guided the fieldwork. However, we wanted to remain open minded in our approach to the field in order to be able to capture themes that were not identified as analytically interesting in advance. This makes the issue about informed consent problematic, as the focus may change somehow throughout the research process (Punch, 1994). Some have even argued that truly informed consent is impossible in qualitative research because it is impossible to anticipate what may happen (Miles & Huberman, 1994). Yet, the researcher must decide how much information beyond the general objective he/she will share with the participants (Fangen, 2005). In Study 2, the seafarers were informed as follows: "At this stage of the study, the focus is broad and will encompass individual, technical and organizational factors that are of significance for safety on board the vessel" and "The study involves collecting data from a sample of vessels – primarily by following the bridge crew in day-to-day operations". In other words, rather than presenting the framework, the research aims were presented to the seafarers in a broader sense. However, the scope of Article II remains within the boundary of the information about the research aims.

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## 4 Findings

This section summarizes the most important findings from the three studies included in the thesis. For a more detailed presentation of findings, the reader is referred to the articles.

### 4.1 How shipboard factors have influenced SA in previous incidents at sea

The main aim of Study 1 was to examine how human, technical and organizational factors had contributed to loss of SA in 23 collisions between offshore vessels and offshore facilities on the Norwegian continental shelf. According to Jones and Endsley's (1996) taxonomy of SA errors, analysis revealed that loss of SA might have been applicable in 18 out of the 23 cases. In 13 cases, loss of SA was related to the first level in Endsley's (1995) three-level model; that is, the bridge crews were not aware of essential SA related information. In four cases, loss of SA was related to the second level; that is, the bridge crews were aware of SA relevant information but did not understand the meaning of it. The last case was related to loss of SA on level three, which involved the failure to project the consequence of a particular manoeuvre. Loss of SA on the first level, caused by the 'failure to monitor or observe data', occurred most frequently in the sample – applicable in eight out of 13 cases. The most common source when it comes to loss of SA on the second level was 'lack of/poor mental model' – applicable in all four cases. The first column in Table 3 below displays the overall findings from the analysis, according to Jones and Endsley's (1996) taxonomy on SA errors.

Acknowledging the fact that human errors caused by loss of SA may be symptoms of underlying conditions, Study 1 aimed at examining how human, technical and organizational factors may have influenced the bridge crews' ability to achieve and maintain SA in the course of events. These results are displayed in Table 3.

Table 3: Contributory causes associated with sources of SA errors

	<b>Contributory causes</b>				
<b>Sources of SA errors</b>					
<i>Level 1 error – perception (n=13)</i>					
Failure to monitor or observe data (n=8)	2	5	4	4	3
Hard to discriminate or detect data (n=1)	1	0	0	1	0
Data not available (n=2)	1	1	1	0	0
Misperception of data (n=2)	1	2	1	0	0
<i>Level 2 error – comprehension (n=4)</i>					
Lack of/poor mental model (n=4)	2	1	1	0	4
<i>Level 3 error – projection (n=1)</i>					
Other (n=1)	0	1	0	1	0
<b>Total</b>	<b>7</b>	<b>10</b>	<b>7</b>	<b>6</b>	<b>7</b>

As shown in Table 3, ‘planning failure’ was the most common contributing factor to the loss of SA – applicable in 10 out of 18 cases. We then defined ‘planning’ as the planning of the approach to the offshore facilities. Examples of planning failures are insufficient risk assessment and the failure to apply mandatory checklists prior to entering the 500-metre safety zone. Further, seven cases involved ‘communication failure’. Examples of communication failure are inadequate transfer of command and the failure to transfer operational information during shift handover. Seven cases involved ‘inadequate design’, which was related both to the layout of the bridge and the design of technical equipment. An example of the latter is inadequate presentation of information in the technical system. ‘Insufficient training’ was applicable in seven cases and was related to inter alia insufficient on-board training. Finally, six cases involved ‘distracting elements’ such as incoming telephone calls and conducting administrative tasks, which in turn drew attention away from navigational responsibilities.

When it comes to a combination of the sources of loss of SA (according to Jones and Endsley’s taxonomy) and contributory factors, ‘planning failure’, associated with the

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‘failure to monitor or observe data’, was identified as the most common – applicable in five out of eight cases. A typical example of this combination is the bridge crew refraining from applying mandatory checklists that may have led to identification of critical indicators in the technical system.

## 4.2 How shipboard practices influence transactions of SA relevant information

Study 2 aimed to follow up on the retrospective analysis of the accident reports in Study 1, by obtaining data from fieldwork on how shipboard practices related to ‘planning’, ‘communication’ and ‘management of distracting/disturbing elements’ play out on board a selection of PSVs in day-to-day operations. The aim of the study was to discuss how shipboard practices regarding these matters might influence the ability to achieve and maintain SA. Acknowledging that it is not possible to examine cognitive processes by means of fieldwork, the theoretical foundation for this study was the theoretical concept of DSA. This approach allows for observations of interactions between different agents on the bridge in order to examine how SA related information is transferred and distributed within the system.

As expected, the study revealed great variations in practices on board the vessels. Some practices were considered favourable, while others were considered unfavourable from a DSA perspective. Table 4 provides an overview of the findings according to the framework for the study. The codes V1-V4 symbolize each of the four vessels that were included in the study. The symbols (+/\*/-) displayed in brackets indicate whether the observable practice was applicable to each of the vessels.

Table 4: Summary of how shipboard practices apply to each vessel

<b>Themes</b>	<b>Observable practices</b>
Planning	Planning of approach as an individual activity: V1 (*), V2 (-), V3 (*), V4 (*)
	Contingency planning as an individual activity: V1 (+), V2 (+), V3 (+), V4 (+)
Communication	Completion of checklists as an individual activity: V1 (-), V2 (-), V3 (*), V4 (*)
	Limited use of standardized communication during transfer of command: V1 (+), V2 (+), V3 (+), V4 (+)
	Inadequate transfer of information during DP operations: V1 (*), V2 (-), V3 (-), V4 (*)
	Limited use of standardized communication during transfer of manoeuvring position: V1 (*), V2 (-), V3 (+), V4 (+)
Distractions and interruptions	Administrative tasks: V1 (*), V2 (-), V3 (+), V4 (+)
	Electronic devices: V1 (*), V2 (-), V3 (+), V4 (+)
	Non-essential conversations: V1 (+), V2 (+), V3 (+), V4 (+)

(+) = *could find*; (\*) = *found a tendency*; (-) = *could not find*

In terms of planning practices, the study aimed to examine practices related to planning the approach to the offshore facilities and contingency planning during operations alongside the offshore facilities. When it comes to planning the approach to the offshore facilities, the study identified various practices. On board vessel V2, planning the approach was consistently performed as a team activity. That is, the bridge crew discussed alternative approaches to the offshore facility before the final decision was made. On board the other vessels (V1, V3, V4), the decision on how to approach and position the vessel alongside the offshore facility was mainly made by



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the officer in command. In contrast to planning the approach, contingency planning refers to a devised plan in the case of an outcome other than the one expected. During the fieldwork, the bridge crews did not openly discuss contingencies. However, when asked, they reported that they were constantly thinking about what might go wrong and how to act if these scenarios should materialize.

Communication practices on board the vessels were examined in relation to a selection of activities that frequently are carried out on board the vessels, that is, during completion of checklists, during transfer of command, during DP-operations and finally during transfer of manoeuvring position. None of the vessels used standardized communication during transfer of command; that is, communication during transfer of command did not follow a standardized procedure such as, “You are now in command” followed by “I am now in command”. However, when it comes to transfer of manoeuvring positions, one of the vessels (V2) used a standardized communication, which also involved closed loop communication. The standardized phrases exchanged between the officer at the aft and the officer at the forward steering position were as follows: “All controls set to neutral position – are you ready?” and “All controls set to neutral position – I am ready.” One of the other vessels (V1) also occasionally used this standardized phrase. On the two remaining vessels (V3, V4), the transfer of command between steering positions was mainly performed by one single officer – making communication irrelevant. Communication while conducting mandatory checklists also varied between the vessels. On one vessel (V1), Officer A cited the items in the checklists, whereas both Officer A and Officer B checked the system independently and reported on the items. On another vessel (V2), Officer A cited items in the checklist, whereas Officer B checked the system and reported back to Officer A. On the two remaining vessels (V3 and V4), the method for completion of the checklists depended on the officer on duty. The general rule on these vessels was that a single officer performed the checklists, with either no communication with the other officer or two-way communication about some of the items. Observations from DP operations on two of the vessels (V1, V4) further indicate that the officer responsible for loading/offloading sporadically acknowledged pre-warnings on the DP system. Pre-warnings are distinguished from

an alarm in the way that they indicate that the vessel's location has started to deviate from the DP set point. It is not critical, but this situation may develop into one in which the vessel deviates from the DP set point in critical terms. Pre-warnings do not provide an audible alarm but are described by text and a colour code on the DP screen. On some occasions, the pre-warnings were acknowledged without communication of the action to the DP operator.

When it comes to the management of interrupting/distracting elements, on board two of the vessels (V3, V4), there seemed to be an acceptance of the use of electronic devices or the performance of administrative tasks simultaneously with the maintenance of navigational activities. On the two other vessels (V1, V2), such activities were seldom or never observed. However, when it comes to interruption/distractions from other crew members, there seems to be limited restriction of access to the bridge on board all the vessels. This in turn caused interruptions/distractions during rather critical phases of the voyage, such as DP-operations alongside the offshore facilities.

### 4.3 How on-board leadership influences SA

The main aim of Article III was to test a theoretical model on how the leadership style (i.e. authentic and laissez-faire) of masters may combine with psychological job demands and influence SA and safe behaviour (i.e. the willingness to take a risk). As mentioned in Section 3.3, the model was tested in both the deck department and the engine department on board 22 offshore vessels belonging to a Norwegian shipping company. Results from the statistical analysis from the deck department sub-sample and the engine department sub-sample are shown in Figures 5 and 6, respectively.

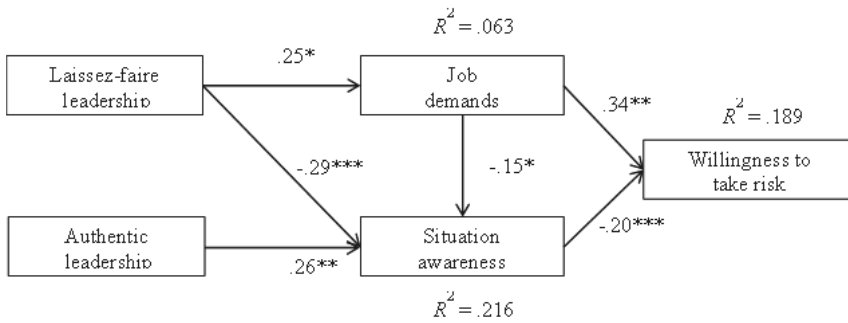


Figure 5: Final model for the deck department sub-sample. Standardized coefficients are shown. SRMR = .042; CD = .225.

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$

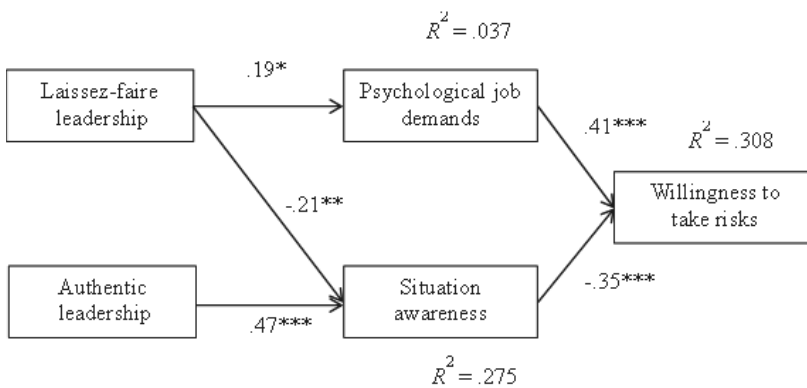


Figure 6: Final model for the engine department sub-sample. Standardized coefficients are shown. SRMR = .051; CD = .301.

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$

An initial path-analysis showed that, in the deck department sample, situation awareness was negatively related to the willingness to take a risk ( $\beta = -.20$ ,  $p = .003$ ). Psychological job demands were negatively related to SA ( $\beta = -.15$ ,  $p = .02$ ), authentic leadership was positively related to SA, while laissez-faire was negatively related ( $\beta = .26$ ,  $p = .002$  and  $\beta = -.29$ ,  $p < .001$ , respectively). Regarding SA, 21.6% of the variations could be explained by the combined influence of authentic leadership, laissez-faire leadership and job demands in the deck department sample. Psychological job demands and SA explained 18.9% of the variations in the

willingness-to-take-risks variable. In terms of model fit, the SRMR indicated a well-fitting model (SRMR for deck department = .042), based on the usual recommendations (Hu & Bentler, 1998; McDonald & Ho, 2002).

In the engine department sample, situation awareness was negatively related to the willingness to take risks ( $\beta = -.35$ ,  $p < .001$ ). Psychological job demands predicted the willingness to take risks ( $\beta = .41$ ,  $p < .001$ ), but SA did not ( $\beta = -.09$ ,  $p = .33$ ).

Authentic leadership and laissez-faire leadership were significantly associated with SA ( $\beta = .47$ ,  $p < .001$  and  $\beta = -.21$ ,  $p = .02$ , respectively). Authentic leadership was 'marginally' significantly associated with job demands ( $\beta = .19$  and  $p = .051$ ).

Laissez-faire leadership was statistically associated with job demands ( $\beta = .19$  and  $p = .048$ ). Laissez-faire leadership could explain 3.7% of the variations in job demands, whereas 27.5% of the variations in SA could be explained by laissez-faire and authentic leadership alone. When it comes to psychological job demands and SA, these two variables explained 30.8% of the variations in the willingness to take risks.

In terms of model fit, the SRMR indicated a well-fit model (SRMR for engine department sample = .051), based on the usual recommendations (Hu & Bentler, 1998; McDonald & Ho, 2002).

With a few notable exceptions, the results support our hypothesized model in both the deck and the engine department samples. In summary, the current study highlights leadership style, psychological job demands and SA as antecedents to risk-taking behaviour. However, some differences between the samples are worth noting. While the effect of job demands on SA proved to be significant in the deck department, it proved to be non-significant in the engine department. Additionally, the effect of authentic leadership on SA appeared to be noticeably stronger in the engine department ( $\beta = 0.47$ ) than in the deck department ( $\beta = 0.26$ ). The most notable difference beyond this was that, in the engine department sample, the combination of job demands and SA explained 30.8% of the variations in the willingness to take risks, compared to 18.9% in the deck department sample.

## 5 Discussion

The main aim of this thesis has been to examine shipboard factors that may influence the ability to achieve and maintain SA on board offshore vessels. In order to do so we designed three studies that, each of which, in its own way, have contributed to this end. In particular, the findings from the overall study have revealed that planning practices, communication practices, management of interrupting/distracting elements, training and experience, design issues and leadership styles are important factors from a SA perspective. In the following, these main findings will be discussed in more detail. The discussion is thematically organized relative to the main findings in the overall study and discussed according to the research problem for this thesis.

### 5.1 Planning and situation awareness

In Study 1, ‘planning failure’ was identified as the most common factor influencing loss of SA in collisions between offshore vessels and offshore facilities – applicable in 10 out of 18 cases. A typical example of an influencing factor that was categorized as planning failure is related to improper use or non-use of mandatory checklists prior to the operation. In general, there seems to be some scepticism in relation to the use of written procedures in the maritime industry. Many seafarers perceive written procedures such as checklists as “counteracting the use of common sense, experience and professional knowledge epitomized in the concept of seamanship” (Knudsen, 2009, p. 295). Although a checklist does not contain SA information per se, it contains items that will ensure that important SA information is paid attention to. A checklist is typically “a list of action items or criteria arranged in a systematic manner, allowing the user to record the presence/absence of the individual items listed to ensure that all are considered or completed” (Hales & Pronovost, 2006, p. 231). For instance, on board offshore vessels, the function of the 500-metre zone pre-entry checklist is to remind the officers to pay attention to a list of predefined variables such as weather conditions and the status of the technical system. From a DSA perspective, checklists may thus be considered as tools to facilitate transactions

of SA relevant information from the external and internal environment to the officers. From a cognitive psychology perspective, they may compensate for our limited capacity in working memory. Wickens (2002) has argued, however, that the use of checklists as a tool to achieve SA falls short in several ways. Firstly, checklists may ensure that important information elements are paid attention to, but they do not necessarily support higher levels of SA (i.e. comprehension and projection of future state). Secondly, in dynamic environments checklists do not take into account unexpected events that may occur. Hence, the officers must continuously stay alert and pay attention to information elements that are relevant in light of their goals – independent of the checklist items. Further, they must be able to comprehend the meaning of the information and project future states in order to achieve the necessary SA for the operation. In this respect, the use of checklists in the planning phase of an operation should be regarded as useful but, on their own, inadequate tools.

When it comes to the items in the ‘500-metre zone checklist’, they vary in nature. Some items do not rely on the officer’s ability to comprehend multiple variables. Rather, they concern one single observation, such as “Autopilot off – yes/no”. Some items, however, place greater demands on the officer’s cognitive abilities such as the item: “Safe direction of approach towards installation evaluated – yes/no”. The evaluation process prior to the final decision on how to approach the offshore facilities varied substantially between the vessels that were included in Study 2: some of the vessels performed it as an individual activity, while others performed it as a team activity. A practice that favours planning the approach as a team activity may facilitate exchange of SA relevant information. In addition, planning as a team activity may provide an opportunity to help each other out in making sense of the situation and to facilitate shared understanding of potential threats and disturbances. In this respect, planning the approach as a team activity may facilitate SA on all levels.

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## 5.2 Communication and situation awareness

In general, the exchange of information and accurate communication is considered a central activity when it comes to our ability to actively maintain SA in teams (Flin et al., 2008); that is, if one officer is in possession of information that another officer needs in order to fulfil his/her role in the system, the information must be communicated to that person (Endsley, 2015; Stanton et al., 2006). In order to do so, it is a prerequisite that the bridge crews have a mutual understanding of each other's roles at all times. There are, however, examples from the accident reports that suggest that the bridge crews' loss of SA was related to misunderstandings regarding each other's roles in the system. Specifically, this concerned misunderstandings regarding who was in command of the vessel. Observations from the field studies offer no reasons to suspect that the bridge crew did not have a mutual understanding of each other's role at all times. However, observed practices regarding transfer of command may be unfortunate and may lay the ground for misunderstandings in future operations; that is, transfer of command was never performed explicitly by means of standardized communication phrases. In general, explicitness in communication is recommended in order to avoid ambiguities, and standardized phraseology and closed loop communication are proposed as a predictable way to communicate in teams (Bowers et al., 1998; Flin et al., 2008; Smith-Jentsch et al., 1998). Overall, I observed limited use of both standardized communication phrases and closed loop communication during the fieldwork. In addition to communication during transfer of command, the field studies focused on communication practices related to transfer of manoeuvring positions, DP-operations and completion of checklists. Misunderstandings in these situations may be critical, and it is thus important that communication between the bridge crew members functions well. Although I observed differences in communication practices between the vessels, we argue that, to prevent misunderstandings, the bridge crews should strive for increased explicitness in communication.

### 5.3 Distractions/interruptions and situation awareness

Due to our limited attention resources, interruptions and distractions such as incoming telephone calls pose a threat to SA (Endsley & Robertson, 2000; Flin et al., 2008; Robertson & Endsley, 1995). Findings from Study 1 indicate that interruptions and distractions preceded loss of SA in six out of 18 cases. In these cases, the interrupting and distracting elements were related to both factors that largely were imposed by the seafarers themselves (e.g. conducting administrative tasks) and factors that were beyond individual control (e.g. incoming telephone calls). In the fieldwork from Study 2, we examined interrupting and distracting elements in day-to-day operations on board a selection of PSVs. Our findings indicate that conducting administrative tasks, using electronic devices and non-essential conversations were applicable in varying degree on board the vessels.

It is obvious that, frequently in day-to-day operations, the bridge crews must simultaneously relate to and manage multiple tasks, such as monitoring parameters in the technical equipment and communicating with other entities. Our findings from Study 3 revealed, however, that psychological job demands have a minor effect on SA in the deck department sub-sample. This finding was surprising since negative factors often associated with overload in job demands such as stress and fatigue had a negative effect on SA in previous studies (Sneddon, Mearns & Flin, 2013). A potential explanation for this finding could be that the seafarers' training and professionalism contributed to a satisfactory SA despite high job demands.

Some research has, however, been conducted into the effect of interruptions on task performance within various industries. According to Trafton and Monk (2007), the research literature has identified two main themes: how the characteristics of the interruptions affect task performance and how to moderate negative effects. In addition, the nature of interrupting and distracting elements may be distinguished according to whether they are caused by factors that are essential or non-essential for the officers' primary task. Although the officers frequently direct attention towards their primary task, distractions and interruptions caused by non-essential tasks might



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still have significant implications for the bridge crews' SA requirements, that is, delayed transactions of SA relevant information because of the failure to switch attention in a timely manner. Further, even if attention is shifted in a timely manner, cognitive effort is required to update SA (Loukopoulos, Dismukes, & Barshi, 2009), which in turn places additional strain on limited cognitive resources. In light of this, the aim should be to eliminate the risk of interruptions/distractions in critical phases of the voyage. This is in line with the aviation industry's 'sterile cockpit rule', which prohibits the crew from performing non-essential tasks in critical phases of the flight (Sumwalt, 1993).

## 5.4 Training and situation awareness

In particular, training and experience are proposed to be a prerequisite to well-developed mental models, which in turn are important to achieve SA on all levels (Endsley, 1995). That is, it is important for the officers to have sufficient knowledge about the system in order to identify relevant information, to comprehend the meaning of the information and to be able to project future states. The results from Study 1 indicate that insufficient training was associated with loss of SA in seven out of 18 cases. In one of these cases, the investigators reported that one of the officers involved had been on board the vessel for less than a week and during this time had not received sufficient familiarization and vessel-specific training. Consequently, the investigators argued that the officer was not aware of what was going on in the course of events prior to the collision (I19-D04 & I19-D02<sup>5</sup>). On-board training, in the sense that senior officers train the cadets and junior officers on board their respective vessels, is an essential part of the shipping companies' training regime. This is of utmost importance, since vessels of the same type in a shipping company's fleet can be equipped with devices from different manufacturers, and these differences can entail significant differences in man-machine interfaces. On-board training and familiarization are thus a prerequisite for establishing sufficient mental models of the

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<sup>5</sup> Refers to the investigation reports in question.

tasks. Conversely, if the officers' work is based on poor mental models, they will be vulnerable to human error caused by loss of SA.

The training regime in the maritime industry has traditionally focused on the development of technical skills, that is, training on technical equipment related to the vessel's core activities, such as training in navigational simulators. However, training methods concerning non-technical skills, including SA, have gained increased attention within the human factor community over the last decade. Training on non-technical skills has also most recently gained increased interest within the maritime industry. For instance, following the 2010 Manila Amendments of the 1978 STCW Convention, the officers on the bridge are required to undergo training in non-technical skills, such as operational leadership and teamwork, in order to retain their certificates (International Maritime Organization, 2011). When it comes to training on non-technical skills that may improve SA, Endsley and Robertson (2000) have suggested some focus areas: training on task management strategies such as management of interruption/distractions; the development of comprehension skills such as evaluation of the risk level; and planning strategies such as contingency planning. Findings from the studies in the present thesis, which suggest that planning, communication and management of distracting/interrupting elements may be important antecedents to loss of SA, indicate that training that aims to improve the seafarers' skills in relation to these matters may contribute to improving SA in day-to-day operations.

## 5.5 Design and situation awareness

From a DSA perspective, technical equipment and other artefacts are considered as important actors in technology driven systems, and analysis of a systems DSA should thus include an analysis of how SA related information is transferred from the technology to the operators (Salmon et al., 2012). In Study 1, inadequate design was identified as a factor that may have influenced the bridge crews' ability to achieve and maintain SA in seven out of 18 cases that were associated with loss of SA. When

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it comes to design of technology, a previous study hypothesized that technological developments on board the vessels were associated with increased risk of loss of SA. The results showed that vessels with more sophisticated technology more frequently were associated with loss of SA than older vessels (Grech, Horberry, & Koester, 2008). To my knowledge, the study did not take into account the possibility that the age of the vessel does not necessarily correlate with the age of the technical equipment on the bridge. These findings may stress the importance, however, of SA-oriented design processes on board the vessels.

Several of the cases included in Study 1 concerned the lack of adequate indicators on the status of the technical system, such as alarms. Examples are lack of an audible alarm when the bridge crew tried to steer the vessel manually with the autopilot activated or lack of an alarm or other adequate indicators in the case of deficiencies in the steering system. Challenges associated with alarms in operational settings were most recently examined in a study within the high-speed vessel segment. Fagerholt and her colleagues (Fagerholt, Kongsvik, Moe, & Solem, 2014) found that 33% of the navigators reported that they always or often experienced alarms that contribute to confusion about the cause of the alarm. In addition, 26% reported that they always or often experienced alarms that were difficult to localize. In general, alarms are indicators of underlying conditions in the system, such as various forms of technical faults. However, alarms must frequently be interpreted in light of other information in the environment in order to fully comprehend the underlying conditions that initiated the alarm in the first place. The cognitive processes involved in the interpretation and integration of information to form higher levels of SA draw on several factors such as our mental models on the system, previous experience with the system, other relevant information in the environment and our experience with system reliability (e.g. false alarm rate). The design of alarm functions must deal with these realities in order to support the bridge crews' SA needs (Endsley, 2012).

## 5.6 On-board leadership and situation awareness

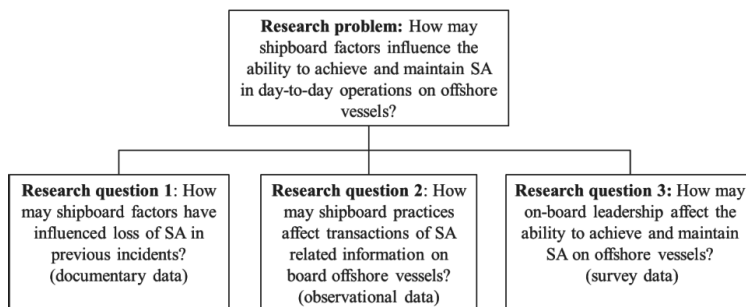
The bridge crew on board an offshore vessel must work in close cooperation in order to execute the operation in a safe and efficient manner. In addition, they have to relate to each other during meals and in recreation facilities on board the vessel. In this respect, the life on board a vessel may be characterized as a “total institution”, as described by Goffman (1961). It is thus a reasonable assumption that the bridge crew members have a considerable influence on each other when it comes to attitudes and work performance. In particular, it is reasonable to believe that, as the vessel’s superior leader, the master will have an influence on work performance and safety on board the vessel. In Study 3, we hypothesized that the master’s leadership style will affect the bridge crew’s ability to achieve and maintain SA in day-to-day operations. The findings showed that authentic leadership was positively associated with SA. These findings were not surprising, since authentic leaders are characterized by high moral standards; it is therefore assumed that authentic leaders will prioritize the safety of the vessel (Hystad, Bartone, & Eid, 2014). Since authentic leaders openly and honestly share information and express their values and viewpoint, it is reasonable to believe that the seafarers themselves will prioritize safety and thus have a greater awareness of safety related information. In this way, they will be able to establish greater SA in relation to their safety goals. Laissez-faire leaders, on the other hand, do not contribute any kind of leadership (Bass, 1997). Hence, the bridge crew have relatively greater freedom in their work performance. Our findings from Study 3 showed that laissez-faire leadership was negatively associated with SA. That is, bridge crews that must relate to masters that practise laissez-faire leadership are at greater risk of losing their SA in day-to-day operations. Since SA is closely linked to decision-making and behaviour (Endsley, 1995), these findings are important for the safety of the vessels. In particular, the findings will have implications for the shipping company’s recruitment and leadership training of masters.

Several researchers have highlighted certain challenges when it comes to authentic leadership in organizations. For instance, Nyberg and Sveningsson (2014) and Wetzel (2015) point to the fact that leaders do not hold an unambiguous role in

relation to the organizations and that leaders may experience a tension between their authenticity and the contradictory expectations of others. For instance, masters on board the vessels might experience a tension between the desire to practise authentic leadership and the expectations from both their own organization and the wider system. For instance, in their day-to-day operations, masters must relate to various actors and cultures (i.e., various authorities, national and international regulations, various charterers and the shipping company's onshore organization), whose requirements are not necessarily in line with their own values and beliefs. Naturally, this may pose a threat to the authenticity of the master's leadership. In other words, it may be challenging or even impossible to practise 'true' authentic leadership in the maritime industry. This should not hinder masters, however, from striving to the greatest extent possible for authenticity in their leadership on board the vessels.

## 6 Conclusion and implications

This thesis has examined and discussed shipboard factors that may influence the ability to achieve and maintain SA in day-to-day operations on board offshore vessels. Figure 7 provides an overview of the overall research problem and the three research questions that were addressed in this thesis.



*Figure 7: The research problem and the research questions*

Research Question 1 was addressed in a study of accident reports concerning collisions between offshore vessels and offshore facilities on the Norwegian continental shelf in the period from 2001 to 2011. The findings indicated that loss of SA was an important contributory factor to various forms of human error on the bridge. The findings further indicated that planning of operations, communication failure, interrupting/distracting elements, inadequate design and insufficient training may have influenced the bridge crews' SA in the course of events.

Research Question 2 was addressed by means of fieldwork on board four different PSVs belonging to two Norwegian controlled shipping companies. The aim of the study was to examine how planning of operations, communication and management of interrupting/distracting elements play out in real-world settings. The field studies revealed various practices on board the vessels. However, in light of a DSA perspective, we argue that increased use of standardized communication, planning as a team activity and better management of interruptions/distractions caused by non-essential tasks would be advantageous from a DSA perspective.

Finally, Research Question 3 was addressed by means of survey data collected on board vessels in a Norwegian controlled shipping company. The findings indicate that, in the deck department sample, 21.6% of the variations in SA could be explained by the combined influence of authentic leadership, laissez-faire leadership and job demands, while, in the engine department sample, 27.5% of the variations in SA could be explained by laissez-faire and authentic leadership alone.

## 6.1 Implications for practice

This thesis has some practical implications for the maritime industry. Firstly, Study 1 revealed that human error caused by loss of SA was a significant contributing factor in previous incidents at sea. Considering the significance of loss of SA, the shipping companies may benefit from applying SA as a framework in future audits, analyses of unwanted events and in accident investigations. By so doing, the shipping companies may identify latent conditions that affect the bridge crews' SA and implement necessary measures. Secondly, the present thesis provides insight into how shipboard practices in day-to-day operations related to planning, communication and the management of interrupting/distracting elements may influence the bridge crews' ability to achieve and maintain SA in day-to-day operations. These findings may support the shipping companies in developing procedures that aim to support the bridge crews' SA. In addition, the study reveals that inadequate design was an important contributing factor to loss of SA. This in turn stresses the need for SA-driven design processes. Study 1 also revealed that insufficient training was an important contributing factor in relation to the failure to comprehend the situation at hand. The shipping companies should therefore provide for both individual technical training and training on non-technical skills. Finally, Study 3 revealed that the masters' leadership style influences the bridge crews' ability to achieve and maintain SA. These findings are important for the shipping companies because they should have consequences for both their leadership training and recruitment processes.

Taken together, the thesis may contribute to an increased focus on SA within the maritime industry. In particular, it is hoped that the thesis will increase the shipping

companies' understanding of how planning, communication, management of interrupting/distracting elements, training, design issues and on-board leadership may influence the seafarers' SA in day-to-day operations.

## 6.2 Implications for theory

This thesis will also have implications for theory. Firstly, the theory of DSA is a rather new theoretical concept within the body of SA theories. As a result, there are relatively few empirical studies on SA as a distributed phenomenon. Since Study 2 favoured a DSA perspective, the thesis adds to our understanding of SA as a distributed phenomenon in the maritime industry. The study might also serve as a window onto studying SA as a distributed phenomenon in other industrial settings. Secondly, our study has contributed with knowledge regarding the significance of on-board leadership from a SA perspective. Since laissez-faire leadership proved to be negatively associated with SA, the thesis also lends support to Skogstad and colleagues' (2007) argument that laissez-faire leadership should be seen as a destructive form of leadership, rather than a type of zero-leadership.

## 6.3 Methodological considerations

An issue that must be discussed regarding the methodology in Study 1 is how suitable accident reports are for examining SA. Obviously, it is not possible to state anything with certainty in respect of the seafarers' cognitive processes in the course of events prior to the collisions. Rather, the classification of SA errors was supported by descriptions of the bridge crews' behaviour and what they were thinking in the course of events. However, this is in line with similar studies that have made use of accident reports for examining the role of loss of SA in previous accidents and incidents. Nevertheless, when it comes to the part of the study that examines factors contributing to the loss of SA, it is fair to admit that it is not possible to state with certainty whether the collisions could have been prevented if the contributing factors, as referred to in Study 1, were not present. Based on the investigators' statements in the accident reports, there are, however, reasons *to believe* that an absence of these



factors would have influenced the bridge crew's ability to perceive SA relevant information, comprehend that information and project future states in a positive way.

I hope that the reader is convinced that the best way to examine shipboard practices in day-to-day operations is by means of fieldwork. However, the methodological approach has its limitations. Firstly, structurally, all the members of the bridge crew had specific duties on board the vessels. The fact that I, as a researcher, did not have any duties on board the vessel might have caused some uncertainty about my role on board the vessel. This in turn might have affected the bridge crews' behaviour and statements. Secondly, a PSV is a high-tech, expert-run system that an outsider without nautical experience is unlikely to fully understand. The use of highly specialized terminology and tacit agreements among the bridge crew members may also have impeded my understanding of the ongoing process on board the vessels. Thus, the reader must bear in mind that this might have affected the quality of the data presented.

In Study 3, we developed a conceptual model, which in turn was tested on survey data collected from a selection of offshore vessels. In this respect, self-report on one's own deviant behaviour may be problematic, as the informants may be reluctant to provide truthful answers. It might therefore be a possibility that the seafarers have underreported their own deviant behaviour for fear of reprisals. On the other hand, self-report may be the most practical measure, as the seafarers are the only ones who are fully aware of their behaviour.

That said, the present thesis presents new empirical evidence that contributes to our understanding of SA and safety outcomes in complex collaborative work systems such as bridge operations in offshore vessels. Based on a multiple method and multiple sample approach, significant shipboard factors that may influence the seafarers' ability to achieve and maintain SA in day-to-day operations have been identified.

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## Situation awareness in bridge operations – A study of collisions between attendant vessels and offshore facilities in the North Sea



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### ABSTRACT

This study examined accident reports ( $n = 23$ ) for collisions between attendant vessels and offshore facilities on the Norwegian continental shelf during the period of 2001–2011. An initial analysis indicated that the concept of situation awareness (SA) might be useful for providing a more detailed understanding of the processes that lead to collisions. SA is defined as 'being aware of what is happening around you and understanding what that information means to you now and in the future' (Endsley, 2012, p. 13). The first part of the study contains an analysis of accident reports that reveals that the collisions with offshore facilities were preceded by loss of SA on the bridge in 18 of the 23 instances. Three types of SA errors were identified: failure to perceive the situation correctly (Level 1 SA;  $n = 13$ ), failure to comprehend the situation (Level 2 SA;  $n = 4$ ), and failure to project the situation into the future (Level 3 SA;  $n = 1$ ). In the second part of the study, the human, technological and organisational factors described in the accident reports are analysed to evaluate how the factors may have affected the duty officers' awareness of the situation. The results indicate that inadequate operation planning, inadequate bridge design, insufficient training, communication failures and distracting elements were the underlying factors that significantly contributed to the collisions.

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### 1. Introduction

During the period of 2001–2011, a total of 27 collisions were reported between attendant vessels<sup>1</sup> and offshore facilities on the Norwegian continental shelf. At least six of these collisions were deemed to have very high hazard potentials (Kvitrud, 2011; Oltedal, 2012). The catastrophic potential of collisions between attendant vessels and offshore facilities was demonstrated in dramatic fashion by the Mumbai High North accident in July 2005. A multipurpose support vessel lost control and hit several marine risers at the Mumbai High North offshore complex off the west coast of India. The collision caused a gas leak that resulted in a serious fire, and parts of the complex collapsed after approximately two hours. Of the 384 persons who were on board that day, 362 were rescued, and 22 died (Daley, 2013). The objective of this study is to

understand the human factors and processes that contributed to the reported collisions on the Norwegian continental shelf to prevent similar events in future. The analysis was based on the assumption that to be effective, bridge crews on attendant vessels must act decisively during stressful, high-risk situations. The analysis also assumed that situation awareness (SA) is a prerequisite for quick and good decisions (Endsley, 1995b). According to Endsley (2012, p. 13), SA can be described as 'being aware of what is happening around you and understanding what that information means to you now and in the future'. That is, the bridge crew must be able to identify key aspects of the environment accurately, understand the meaning of what they sense, and have a good sense of what can happen. Although we have no data to verify that SA errors contributed to the Mumbai High North accident, the available information strongly suggests that a loss of SA might have been a contributing factor. The weather conditions were unfavourable when the vessel approached the offshore facility on its windward side. Due to technical problems, the approach was initially made in manual mode and, subsequently, in emergency mode, which indicates that the vessel's position was entirely under human control (Daley, 2013). In such conditions, it is particularly important that the bridge crew is attentive and has the ability to assess the situation continuously and act appropriately to avoid severe consequences. Any collision between seagoing vessels and fixed installations, such as bridges and quays, has the

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<sup>1</sup> This term refers to vessels that provide services to offshore installations and includes platform supply vessels (PSVs), anchor-handling vessels, standby vessels and oil tankers. Historical data show that 98% of collisions between vessels and offshore facilities on the Norwegian continental shelf involve attendant vessels (the North West European Area Guidelines, 2009).

potential for major consequences to human, environmental and economic assets. However, as shown in the Mumbai High North case, collisions with offshore production facilities have notably high hazard potentials. In addition to the risk of injuries and fatalities, damage to hydrocarbon pipes and subsequent ignition and fire may cause severe oil spills and thus represents a threat to marine life and vulnerable ecosystems.

In the current study, we examined 23 of the 27 collisions that occurred in the period from 2001 to 2011 to determine the role of human errors that might have been related to the loss of SA. However, because human error caused by the loss of SA can be perceived as a consequence of the underlying circumstances in an organisation (Reason, 1997), the current study also aimed to identify the human, technological and organisational factors that might have influenced the bridge crews' abilities to achieve and maintain SA as the events unfold. The incidents that we analysed occurred within a petro-maritime context in which various organisations and actors, including both internal actors on board the vessel and external actors (e.g., the offshore facility), interact on a daily basis. However, our primary emphasis was on the bridge operations, and our study is therefore limited to the course of events on the bridge. To provide a frame of reference, we will briefly outline the concept of SA and suggest several factors that might have affected the bridge crews' SA formation.

### 1.1. The concept of situation awareness

According to Endsley (1995b), SA in bridge operations generally involves three levels of information processing. At the first level (SA Level 1), the duty officer perceives the status and dynamics of the relevant elements in his/her environment. Given that our attention and working memory capacities are limited and selective (Simons, 2000), a typical error at this level would be the missing of critical information. At the second level (SA Level 2), the duty officer will integrate and evaluate the information at hand. He/she is required to understand the perceived information in relation to the relevant goals and objectives. Because our attention and working memory capacities are limited, we rely on information stored in our long-term memory in the form of particular mental models (Endsley, 1995b). A mental model can be understood as '*the mechanisms whereby humans are able to generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states*' (Rouse and Morris, 1986, p. 351). Thus, a typical error at the second level would be a failure to comprehend the situation. The duty officer might misinterpret the information or experience limitations in working memory due to information overload and/or stress (Endsley, 2012). At the third level (SA Level 3), the duty officer uses his/her perception and comprehension of the current situation to estimate what will happen in the near future (Endsley, 1995b). For example, by calculating speed, currents and wind, the duty officer should be able to avoid a collision with an offshore facility by reprogramming the automatic systems.

As proposed by Endsley, the three-level approach focuses on cognitive processes and takes the mind of each individual as the unit of analysis. However, this approach has certain limitations in terms of our understanding of how SA is achieved in collaborative systems. In this respect, a more recent perspective on SA provides an alternative manner in which to examine SA. Following from the concept of distributed SA, SA is viewed as a system property in which SA related information is distributed between different agents (both human and non-human) in a collaborative system. In this perspective, the focus of study is on the interactions between the agents comprising the system, and a central aim is to understand how SA-related information is transferred between different agents in day-to-day operations (Salmon et al., 2012). In this

manner, the application of a distributed SA perspective may enhance our understanding of the factors that influence SA formation among the bridge crew. Communication is a particularly critical dimension that might be a source of misinformation and thus affect a bridge crew's SA requirements (Kanki, 2010; Patrick and Belton, 2003; Weick et al., 1999). Should a crew member fail to transfer information or communicate information in an ambiguous manner, the bridge crew's SA formation might suffer (Endsley, 1995b). The technological environment of the bridge also provides SA-related information; thus, man-machine interactions are of particular importance on board offshore vessels. The extent to which and how the technology provides the bridge crew with information is therefore a critical dimension in the SA context (Endsley, 2012). It has also been suggested that planning activities aimed at anticipating events might have a positive effect on bridge crews' abilities to achieve SA. High-quality planning should ideally improve the understanding of risk and enable crew members to seek information in advance and plan for various scenarios (Endsley and Robertson, 2000; Flin et al., 2008). Such planning may be particularly important in situations in which the bridge crew has limited time to act to avoid consequences. In addition to highlighting interactions with both humans and the environment, Bolstad et al. (2005) emphasised that the operators' abilities are a central component in the formation of SA in collaborative systems. From this perspective, emphasis should be placed on factors such as training regimes, including how the shipping companies ensure that the bridge crew has sufficient knowledge to understand what they sense.

The loss of SA is frequently seen as an important contributing factor to accidents in various industries, such as the aviation (Endsley, 1995a; Jones and Endsley, 1996) and maritime industries (Barnett et al., 2006; Grech et al., 2002). An accident analysis from the offshore drilling industry indicates that the loss of SA is a significant antecedent of human error. Of the 135 cases that were associated with a loss of SA, 67% were attributable to a lack of perception of critical information (SA level 1), 20% were attributed to a failure to comprehend the situation (SA level 2), and 13% were attributed to an inability to project the situation into the near future (SA level 3) (Sneddon et al., 2006). To the best of our knowledge, no previous studies have examined the significance of the loss of SA during bridge operations on board offshore vessels.

### 1.2. International standards and industry guidelines

Several international standards and guidelines have been developed to support seafarers and help them operate safely at sea. The oldest such standard is the International Convention for the Safety of Life at Sea that was developed by the International Maritime Organization as a response to the Titanic disaster. This convention was adopted in 1914 and was most recently revised in 2011. The main objective of this convention is to specify minimum standards for the construction of and equipment on board vessels. Of particular significance in the SA context is the principle that bridge design and the design of navigational systems and equipment should enable the bridge crew to have convenient and continuous access to essential information that is provided in a clear and unambiguous manner (International Maritime Organization, 2012). Furthermore, following a series of major accidents at sea in the early 1990s, the International Maritime Organization began to develop new regulations that account for human factors (Gholamreza and Wolff, 2008). This update included a new revision of the Standard for Training, Certification and Watch-Keeping for Seafarers (International Maritime Organization, 2011) that incorporated new minimum requirements for the training and competence of seafarers and thus aimed to increase the knowledge and skills of seafarers worldwide. This update also included a

revision of the International Safety Management Code (International Maritime Organization, 2010) that aimed to establish a minimum standard for safety management systems (Rodríguez and Champbell Hubbard, 1998–1999). However, because the code sets out functional requirements, rather than specific operating procedures, the industry is still relatively free to customise its safety management systems to its own needs within the framework of the code. A recent example is the North West European Area (NWEA) guidelines for the safe management of offshore supply and anchor-handling operations.<sup>2</sup> These guidelines were developed as a joint project by maritime and offshore organisations in Denmark, the Netherlands, the UK and Norway, and they were implemented in 2006. The purpose of these guidelines was to incorporate the best practices in offshore supply and anchor-handling operations into the industry (the North West European Area Guidelines, 2009). Although the NWEA guidelines are officially only recommendations, in reality, clients require shipping companies that provide supply and rig moving services to adhere to them. Several requirements that were incorporated into the NWEA guidelines were intended to increase the awareness of bridge crews of the situation and the upcoming operations, for example, by mandating that two navigators are on the bridge when operating inside the safety zone around an offshore facility and by providing checklists and standards for risk assessment that must be completed and met prior to entering the safety zone. International standards and industry guidelines can thus be seen as structured recommendations that are intended to assist bridge crews in their work performance.

## 2. Methodology

### 2.1. Sample description

The objective of this study was to understand the human factors and processes that contributed to the 27 collisions between attendant vessels and offshore facilities on the Norwegian continental shelf in the period of 2001 to 2011. The only available data about these incidents are presented in reports from various investigations, and this study is based on reviews and analyses of the data presented in these reports. Initially, we were able to collect reports about 24 of the incidents, but one was excluded due to sparse information. Three of the incidents included in this study were investigated by more than one agency or organisation, resulting in a total of 28 accident reports. In these three cases, the accident reports dealing with the same accident provided richer sources of information about the cases in question. However, the suggested causes were not counted more than once. Ten reports originated from operators, fourteen from shipping companies, two from consulting firms in cooperation with shipping companies, one from the owner of the offshore facility and one from the Norwegian Petroleum Safety Authority. The reports varied in length from 4 to 63 pages, and the total number of pages including appendixes was 701. Table 1 presents an overview of the types of vessels that were involved in the incidents, and Table 2 provides an overview of the types of operations that were being conducted at the times of the incidents.

### 2.2. Procedure

The coding was quite a challenge because the reports were surprisingly diverse in terms of their contents, structures and applied methodologies. Indeed, the methodologies were only explicitly described in seven of the reports. In the remaining 21 reports,

**Table 1**

Type of vessels involved in the incidents.

Type of vessel	No of incidents
Platform supply vessel	17
Anchor-handling vessel	2
Standby vessel	2
Shuttle tanker	1
Well stimulation vessel	1

**Table 2**

Type of operation being conducted at the times of the incidents.

Operation	No of incidents
Loading/offloading	10
Approaching offshore facility	8
Departing from offshore facility	2
Anchor handling	2
Stand-by services	1

the methodologies used to arrive at the findings and conclusions were unknown. However, all of the reports contained statements about the original investigators beliefs regarding the causes of the incidents. To select the most appropriate approach for analysing the accident reports, these statements were initially reviewed and organised into major topics. The results indicated that human error (caused either directly by the bridge crew or by inadequate responses to technical faults), technical faults and adverse weather conditions emerged as the major causal categories, and causal categories were implicated both separately and in combination. Twenty-one cases involved some type of human error, nine cases involved some type of technical fault, and six cases involved adverse weather conditions (e.g., heavy fog, swells and waves). In eight cases, human error occurred in combination with a technical fault, in five cases, human error occurred in combination with adverse weather conditions, and in the remaining eight cases, human error was identified as the sole direct cause.

Based on the initial processing of the reports, we decided to follow an approach that remained open to organizational, technological, individual factors and environmental force-related factors. The second analytical step consisted of a process of open and axial coding (Neuman, 2006) and provided opportunities to develop categories that described the causal factors and to examine the associations between categories. In this process, failures related to 'problem detection' and 'problem diagnosis' emerged as two major categories of human error that contributed to the incidents. These categories were considered to be congruent with Level 1 and Level 2 in Endsley's (1995b) theory of situation awareness, and this concept therefore emerged as a major topic of the study.

Initially, we intended to end the procedure after the second step. However, due to the identified link between the categories and the theory of SA, we decided to elaborate further on the significance of the loss of SA. Consequently, a further analysis focused exclusively on the 21 cases in which the incidents were caused by human error alone or in combination with weather conditions or technical faults. The third analytical step therefore involved the use of Jones and Endsley's (1996) conceptual framework, which classifies and describes the sources of SA errors at each of the SA levels, to reanalyse and reclassify the information about the causes presented in the reports. In cases in which more than one SA error was identified, we only coded the error that occurred closest in time to the collision.

Because the previous analytical steps were not sufficient to understand why the losses of SA occurred, we decided to extend the analysis to identify the contributing factors. In the fourth step, each accident report was re-examined to identify the human, technological and organisational contributing causes associated with

<sup>2</sup> The NWEA guidelines were replaced by Guidelines for Offshore and Marine Operations (GOMO), which were implemented on the 1st of June 2014. However, the NWEA guidelines were applicable at the time of the collisions included in this study.

the SA errors. These contributing causes were assigned an initial code, and the codes were later condensed into broad categories. For example, 'insufficient risk assessment', 'inadequate use of the pre-entry checklist' and 'insufficient technical tests' before the vessels entered the offshore facilities' safety zones were all categorised as 'planning failure'. In addition to 'planning failure', 'inadequate design', 'communication failure', 'distracting elements' and 'insufficient training' emerged as major categories.

Finally, to increase the reliability of the coding, the reports were independently analysed and classified (according to the SA conceptual framework) by two of the authors. Both authors remained blind to the other's classifications during this process. The raters agreed in the majority of the cases. In cases of disagreement, the raters discussed the cases and reached agreement by clarifying and explaining their positions. In all but two cases, the raters reached agreement about their classifications. For these two cases, a third rater analysed and classified the accident reports. The final classifications were in accordance with the classifications of the majority. The two cases in question are marked with asterisks (\*) in Table 5.

### 2.3. Methodological challenges

As noted in previous studies that have analysed accident reports, the present study contains limitations and shortcomings concerning the ability to represent all aspects of an incident; '[all such reports] are – even the best of them – a highly selective version of the actuality, and it is also very much a subjective process' (Reason, 2008, p. 58). Although the accuracy of a report can never be known with any degree of certainty, it is important to identify the conditions that might have led to inaccuracy (Scott, 1990). As previously noted, the accident reports were surprisingly diverse in terms content, structure, and applied methodology. Although some of the reports contained a relatively comprehensive analysis, it should be noted that some of the reports contained rather sparse information beyond the acute phase of the incident and emphasised technical faults and human error. Therefore, it is likely that the organisational contributing causes were underrepresented in the sample. Thus, the distribution of contributing causes might be somewhat distorted relative to the actual distribution. Because the methodologies applied in the investigations were not explicitly described in the majority of the reports, it is also difficult to assess whether and how various SA aspects were covered in the investigations. In addition to the arguments outlined above, an important question is whether the researchers were able to draw the correct conclusions based on the data presented in the accident reports. Although the data utilised in this study consists of the investigators' descriptions of the incidents and their beliefs regarding the causes of the incidents, the coding process always includes subjective judgements. For example, in the present study, failures to apply the mandatory checklists before the vessels entered the offshore facilities' 500-m safety zones were coded as 'planning failures'. Another code that might have been applicable in these cases is 'procedure violation', which would have communicated another aspect of the causal picture. However, we attempted to establish transparency in this study such that the description of the incidents and associated contributing factors are presented as narrative text to a large extent. The reader must however bear in mind that the reliability of this study might be affected by the aforementioned conditions.

### 3. Results

The cases included in our study varied in relative severity, both in terms of actual consequences and loss potential. The majority of

**Table 3**  
Consequences.

Severity rating	Consequences	No of incidents
Minor	Minor or no material damage to facility and/or vessel Examples: minor damage to railing, antennas, fender lists, bulk hoses and minor dents in bulwark	15
Severe	Considerable material damage to facility and/or vessel Examples: dents in shaft and bracing on the offshore facility and dents in the vessels hull	8

the cases ( $n = 15$ ) involved minor impacts with the offshore facility and limited to minor material damage to the offshore facility and/or vessel. Typical scenarios in these cases were that the vessel drifted into the offshore facility due to technical problems or due to inattentiveness by the bridge crew. Thus, in these cases, relatively low amounts of force were involved. Additionally, the bridge crews were able to restore normal states by pulling out from the offshore facility relatively swiftly. The remaining cases ( $n = 8$ ) were assessed either by the Norwegian Safety Petroleum Authority or the service provider as having severe loss potentials. In these cases, the vessels hit the offshore facility at relatively high speeds<sup>3</sup> or made contact with the offshore facility repeatedly due to problems pulling out from the offshore facility and restore a normal state. Table 3 provide some examples of the actual consequences according to severity rating.

According to the accident reports, the wind speeds were at *calm* and *high wind*, *moderate gale*, and *near gale* levels at the times of the incidents. However, no information about wind speed was available in three of the accident reports. In two other reports, the wind speeds were described as light and thus could not be classified according to Beaufort's scale. The wave heights at the times of the incidents according to the accident reports were between zero and six metres.<sup>4</sup> However, in three of the accident reports, no information about wave height was available. In two other reports, the conditions were described as calm seas. An overview of the weather conditions at the times of the incidents is provided in Table 4.

SA errors were identified in 18 of the 21 cases we analysed. Table 5 provides an overview of the classifications of these 18 cases according to Jones and Endsley's (1996) conceptual framework. Thirteen incidents were classified as Level 1 errors, four cases were classified as Level 2 errors, and one case was classified as a Level 3 error. Regarding the SA Level 1 errors, the most common source was a 'failure to monitor or observe data', which was applicable in 8 of the 13 cases. The most common source of the Level 2 errors was a 'lack of/poor mental model', which was applicable in all four cases. The incident classified as a Level 3 error was due to a failure to project the possible consequences of a particular manoeuvre when the vessel was about to leave the offshore facility. In twelve of the cases, the bridge crew failed to perceive or comprehend critical information regarding the vessel's technical status.

Table 6 provides an overview of contributing causes that were associated with each source of SA error according to Jones and Endsley's (1996) conceptual framework. The column on the left shows the numbers of incidents associated with each source of SA error as presented in Table 5. The remaining columns show the numbers of cases associated with each category of contributing cause as identified in our analysis.

Overall, 'planning failure' was identified as the most common contributing cause and was applicable in 10 of the 18 cases. The

<sup>3</sup> In one of the cases the vessel collided with the offshore facility at a speed of 9.7 knots.

<sup>4</sup> In nine cases, whether the wave height was measured as significant or maximum wave height was not specified. In four cases, wave height was significant wave height, and in three cases, it was measured as maximum wave height.



**Table 4**

Weather conditions.

Wind speed	Wave height	Number of incidents
Fresh breeze – high wind, moderate gale, near gale (17–33 knot)	0–4 m	7
Fresh breeze – high wind, moderate gale, near gale (17–33 knot)	1.5–6 m	11
Fresh gale – hurricane (34 knot– ≥64 knot)	N/A	0
Described as light wind	Described as calm sea	2
Information not available	Information not available	3

**Table 5**

Sources of SA errors according to Jones and Endsley's (1996) conceptual framework.

Level of error	No of incidents
<i>Level 1 error – perception</i>	13
Failure to monitor or observe data	8*
Hard to discriminate or detect data	1
Data not available	2
Misperception of data	2
Memory loss	0
<i>Level 2 error – comprehension</i>	4
Lack of/poor mental model	4
Use of incorrect mental model	0
Over-reliance on default values	0
Other	0
<i>Level 3 error – projection</i>	1
Lack of or incomplete mental model	0
Over-projection of current trends	0
Other	1

next most common causes were 'inadequate design', 'communication failure' and 'insufficient training', which occurred in seven of the 18 cases. 'Planning failure' in combination with 'failure to monitor or observe data' was identified as the most common contributing cause among the SA Level 1 errors and was applicable in five of eight cases. The most common contributing cause among the SA Level 2 errors was 'insufficient training' associated with 'lack of/poor mental model', which was applicable in all four cases. In the following sections, we elaborate on our findings and provide examples drawn from the accident reports in accordance with the structure provided by Jones and Endsley's (1996) conceptual framework.

### 3.1. Level 1 error – perception

#### 3.1.1. Failure to monitor or observe data

In eight cases, the source of the SA error was the bridge crew's failure to monitor or observe critical available information. In five of these cases, the bridge crew failed to detect settings in the vessel's technical system. Notably, two cases followed an almost identical course of events in that they were both caused by the bridge

crew believing that the vessel was on manual steering when it was actually on autopilot. Because the autopilot overrides manual steering, all attempts to steer the vessel failed, which led to unavoidable impact with the offshore facility. After one of the incidents, the investigators stated, 'he [the officer] checked critical functions (...) but he did not check the status of the autopilot' (Report no I06 – D01, p. 8). The last three cases were due to insufficient monitoring of the vessel's relative distance to the offshore facilities. In one of the accident reports, it was noted that 'both the master and the first officer were present on the bridge on [name of the vessel] when the vessel was within the 500-m safety zone of [name of the installation], but for a while, no one kept lookout in the vessel's longitudinal direction' (Report no I15-D02, p. 15) (translated from Norwegian into English). When the bridge crew's attention was finally drawn to the longitudinal direction, it was too late to reverse the situation because the vessel was critically close to the offshore facility.

The investigators emphasised what has been classified as 'planning failure' as the most common contributing cause associated with the 'failure to observe or monitor data', which was applicable in five of the eight cases. In three of these five cases, more active use of the available checklists during the planning stage before the vessel entered the offshore facility's safety zone might have helped the bridge crew to perceive critical data from the vessel's technical system. The second most common contributing causes associated with 'failure to monitor or observe data' were 'communication failure' and 'distracting elements', which were both applicable in four of the eight cases. Regarding 'communication failure', two cases were related to ambiguities in communication during the transfer of command. In one of these cases, the ambiguity in communication led to confusion about who was actually in command of the vessel. The investigators stated that 'the master was of the opinion that the first officer was in command of the vessel (...). The master did not monitor the vessel's position, while the first officer took it for granted that the master was in control and command of the vessel' (Report no I09-D01, pp. 12–14). That no one was in command resulted in an unmonitored approach to the offshore facility. Regarding 'distracting elements', these elements stemmed from incoming telephone calls, the performance of administrative tasks and distractions due to other activities on deck. These

**Table 6**

Contributing causes associated with sources of SA errors.

Sources of SA errors	Contributing causes				
	Inadequate design	Planning failure	Communication failure	Distracting elements	Insufficient training
<i>Level 1 error – perception (n = 13)</i>					
Failure to monitor or observe data (n = 8)	2	5	4	4	3
Hard to discriminate or detect data (n = 1)	1	0	0	1	0
Data not available (n = 2)	1	1	1	0	0
Misperception of data (n = 2)	1	2	1	0	0
<i>Level 2 error – comprehension (n = 4)</i>					
Lack of/poor mental model (n = 4)	2	1	1	0	4
<i>Level 3 error – projection (n = 1)</i>					
Other (n = 1)	0	1	0	1	0
Total	7	10	7	6	7

activities are believed to have reduced the bridge crew's attention to the navigational activities.

### 3.1.2. Hard to discriminate/detect data

One of the incidents included in our study was caused by the bridge crew's difficulty in detecting critical information because the vessel was moving between offshore facilities in the dark and in heavy fog. Due to the visibility conditions, the crew failed to detect one of the offshore facility's legs, which resulted in a minor impact.

The investigators emphasised both factors that were classified as 'inadequate design' and 'distracting elements' as potential contributing causes of the incident. Firstly, regarding design issues, it was noted that due to the shape of the bridge, the bridge crew was not able to see parts of the offshore facility from the manoeuvring position. Additionally, it was noted that the legs of the offshore facilities were painted a dark colour that was difficult to discern in reduced visibility conditions. Secondly, regarding 'distracting elements', the accident report stated that a moment of inattention by the master due to VHF communication contributed to the incident.

### 3.1.3. Data not available

In two cases, critical information concerning the state of the vessel's technical system from the bridge was not accessible (in due time). In one of the cases, a technical fault in one of the thrusters was a contributing cause to the incident, but because the joystick manoeuvring system did not have a system for monitoring the individual movements of the thrusters, the bridge crew received no failure warning before beginning to position the vessel close to the offshore facility. The other case was related to faulty settings in the dynamic positioning<sup>5</sup> (DP) system. A mishap that occurred while making adjustments to the DP system resulted in a situation in which the joystick's references regarding forward and stern were switched relative to the expectations of the bridge crew. There were no indicators available on the bridge that could have informed the crew about this faulty setting at the time of the incident.

According to the investigators, 'inadequate design' was a contributing cause of the first incident because there was reason to believe that the incident could have been prevented if the design of the technical system had supported the information needs of the bridge crew regarding the status of the thruster. In the second incident, the investigators highlighted what were classified as a 'planning failure' and a 'communication failure' as contributing causes. The accident report states that it was common procedure on board the vessel to test all functions of the DP system before the vessel enters an offshore facility's safety zone. Thus, although the functions were not tested, after making adjustments to the DP, the bridge crew could have detected the faulty settings in the planning stage if the mandatory test of the DP had been performed. However, the adjustments to the DP were performed in cooperation with the DP manufacturer, who helped the bridge crew with the software via phone. In this context, the investigators noted that the communication between the involved parties, particularly the information received from the manufacturer, was not sufficient.

### 3.1.4. Misperception of data

Two of the cases were related to misperceptions of available information. In the first case, the bridge crew assessed the current direction as be northeast, but it was actually southwest. In the

investigators' view, this misperception played an important role in the course of the events. In the other case, the vessel approached the offshore facility on autopilot, and all attempts to steer the vessel manually failed. According to the investigators, the duty officer stated that he performed a functional test of the rudders prior to entering the safety zone and that he was convinced that the rudders were working in manual mode. However, this perception proved incorrect.

In the first case, both 'communication failure' and 'planning failure' might have contributed to the bridge crew's misperceptions. Regarding the 'communication failure', the accident report highlighted that the previous shift had kept the vessel outside of the safety zone for a while and would have had information about the current conditions, but this information was not transferred during the shift changeover. The investigators also noted that according to standard procedure, the weather conditions, including how the current is affecting the positioning of the vessel, should be assessed approximately 50 m away from the offshore facility. Because this assessment was not performed, the bridge crew missed an opportunity to reassess the perceived current conditions while planning the approach to the offshore facility. In the second case, the 'planning failure' might have contributed to the incident because the investigators emphasised that the technical systems were not checked before entering the safety zone in accordance with the vessel's procedures.

## 3.2. Level 2 errors – comprehension

### 3.2.1. Lack of/poor mental model

In the four cases that were classified as SA Level 2 errors, the bridge crews perceived critical information but failed to comprehend its meaning. All four cases are believed to have been caused by a 'lack of or poor mental models', and all of these incidents were related to a type of miscomprehension of the status of the vessel's technical system. One of the incidents occurred when the vessel's DP was activated during a loading/offloading operation alongside an offshore facility. Due to a known failure in a computer card, one of the propeller units was deselected in the DP. Although the redundancy requirements for the DP operation were not met, the bridge crew decided to perform the operation because they thought it would be sufficient to use the deselected propeller unit as a manual backup. At some point, the DP reference systems were lost, and the vessel began to drift towards the offshore facility. In an attempt to reverse the situation, the bridge crew attempted to stop the movement by utilising the deselected propeller unit while the vessel's DP system was still activated. As a consequence of operating the system in this manner, a strong force that the DP system was not aware of was introduced. Consequently, the vessel continued to drift towards the offshore facility with the DP system activated, while the manual use of the deselected propeller unit caused a strong rotation that led the forepart of the vessel to collide with the offshore facility. According to the investigators, 'Apparently, the crew were not aware of the risk involved and the effect of operating with the system configured as it was' (Report I08-D01, p. 12).

'Insufficient training' was believed to be a common contributing cause in all four of the cases that were associated with 'lack of/poor mental models'. Two of the accident reports highlighted relatively comprehensive deficiencies in training. For example, in the case outlined above, the investigators stated that 'no systematic training was given in handling the vessel or training on a simulator, despite several of the navigators having no experience of this DP control system, limited or no experience in the handling and use of diesel electric propulsion, and operations close to offshore installations' (Report no I08-D01, p. 18).

<sup>5</sup> DP is an advanced automated manoeuvring system that is based on positioning reference systems such as global positioning systems.

### 3.3. Level 3 errors – projection

#### 3.3.1. Other

One case in our sample was classified as an SA Level 3 error, indicating that the bridge crew failed to project future states. In this case, the duty officer was positioning the vessel using the joystick control. When the loading operation commenced, the vessel was not in a stable position and was still drifting towards the offshore facility. At approximately the same time that the crane hook was disconnected from the deck load, the duty officer noticed that the gyro repeater had lost its signal, and he therefore decided to switch from joystick to manual control to pull back from the offshore facility. However, because the vessel was still drifting towards the facility, he failed to project the consequences of his counter manoeuvre. Consequently, the stern drifted towards the offshore facility and made contact with one of its legs.

'Distracting elements' and 'planning failure' were identified as contributing causes in the incident. It was noted in the accident report that a possible contributing factor to the incident was the fact that the duty officer was distracted by the gyro repeater. Additionally, the report highlighted that the vessel should have been, but was not, in a stable position before the loading operation commenced.

## 4. Discussion

The present study presents a comprehensive analysis of the collisions between attendant vessels and offshore facilities on the Norwegian continental shelf over a 10-year period. Our primary aim was to determine the role of SA in these collisions. The results indicated that SA errors likely have preceded the collisions in 18 of the 21 cases. In this context, SA errors should not be confused with decision errors because the duty officers believed that they had made the right decisions based on their perceptions and assessments of the situations. However, due to inadequate situational assessment, as judged by the subsequent collisions or significant breaches of safety barriers, their actions were demonstrated to be wrong.

Notably, 12 of the 18 cases associated with SA errors were related to the vessel's technical status, e.g., missing critical information regarding the vessel's steering mode or deficient comprehension related to the status of the technical system. These findings may not be surprising because the bridge crew's duties on board attendant vessels largely involve operating and monitoring technology. In this context, it is notable that in the last decade, the overall technical system in the bridge has developed towards increased automation (e.g., electronic maps and dynamic positioning systems) with the intention of improving operational efficiency and safety (Dekker, 2005; Lee and Moray, 1994). However, the bridge crew still plays a crucial role in the control of these systems. For example, DP keeps the vessel in a fixed position that is consistent with the bridge crew's programming of the system. However, the bridge crew needs to monitor parameters, respond to alarms and diagnose failures to maintain safe operations alongside the offshore facilities. Such activities can be taxing, and automation may therefore provide the illusion of a reduced workload while, in reality, increasing the workload (Bhardwaj, 2013). In contrast to the tasks entrusted to the automatic systems, those entrusted to the bridge crew rely on demanding cognitive processes, such as sustained attention, perception and diagnostic skills. In this context, it is also significant that automation often adds to the complexity of a system, which in turn, can cause human performance problems. Perrow (1999) took a rather deterministic stand when he claimed that accidents are unavoidable in systems that are characterised by complex interactions and tight couplings. Accidents are

bound to happen due to characteristics such as a limited understanding of the system, indirect information from the monitors and alarms, time-dependent processes and little room for error in the system. One of the main problems of complex systems is that they challenge the operator's ability to form reliable mental models of how the system works (Endsley, 2012; Parasuraman and Riley, 1997). Complexity may consequently slow the ability to detect a failure or other important information. Furthermore, complexity challenges the operator's ability to comprehend the information correctly and project future states. Although vessels using DP in close proximity to the offshore facilities have built-in technical redundancy, there is little room for error if the technology fails because the time that is available for a response is notably limited. In such situations, it is of the utmost importance that all failures are detected early and correctly diagnosed and that the crew acquires manual control when necessary.

Our analysis identified six sources of SA errors among which 'failure to monitor or observe data' associated with SA Level 1 errors was the most common source of failure. These results are in line with similar studies from the aviation (Jones and Endsley, 1996), offshore (Sneddon et al., 2006) and marine transport (Grech et al., 2002) industries that have also indicated that most common types of SA failures are related to situations in which all of the information are available, but that information is not perceived by those involved. In this context, it is notable that the number of items of equipment at the main workstation increased from 22 to 40 during the period of 1990 to 2006 (Lützhöft et al., 2006). Correspondingly, on a randomly selected offshore vessel, the DP operator is required to retrieve information from 6 monitors and 17 control panels of varying sizes at the DP station, which requires the switching of attention between various computer systems while also attending to the surrounding environment. Therefore, there is a risk of missing critical information. Organisational redundancy might also be a factor that should be considered in this respect. Redundancy in the form of manning the bridge with two navigators while operating inside an offshore facility's safety zone would in principle facilitate safety because the officers could monitor each other and raise critical questions (Rosness, 2001). However, there is evidence from our sample that the implementation of this principle could have both positive and negative effects. Failures to clarify the division of labour could lead to incorrect assumptions about who is responsible for specific tasks, which in turn, could lead to insufficient monitoring of critical information.

Finally, in recognition of the limitations of a solely SA-centred approach, our final aim in this study was to examine whether human, technological and organisational factors might have affected the bridge crews' abilities to achieve and maintain SA. In our analysis, we divided the contributing causes into five categories and found that 'planning failure' was the most significant factor overall. In the planning phase, the bridge crew is required to retrieve information from various sources to decide on the most favourable approach and positioning of the vessel alongside the offshore facility. Among others, these information sources include weather forecasts, personnel from the offshore facilities and technical equipment on board the vessel. Therefore, it is important that the bridge crew pays attention in the planning phase to obtain the necessary SA for operation. A majority of the cases associated with 'planning failure' can be regarded as incidences of procedural violations. According to the shipping companies' safety management systems and the NWEA guidelines, the bridge crews are supposed to use checklists that contain items such as the status of the vessel's technical system, weather conditions and communication lines prior to entering an offshore facility's safety zone. Although checklists do not contain SA information per se, they contain items that are meant to ensure that the important SA information is retrieved and considered during the planning phase. In this

manner, checklists are important tools in the process of achieving SA prior to entering an offshore facility's 500-m zone. However, when failures to comply with mandatory checklists are observed, it is necessary to understand why the procedural violations occurred and not simply ascertain that they have occurred (Dekker, 2005). Although the accident reports included in our study seldom provided explanations in this context, research suggests several potential explanations. For example, Rasmussen (1997) highlighted that factors such as production pressure and individual motivation to exert less effort may lead to violations of safety procedures. Dekker (2005) also emphasised that procedural violations can be viewed as sensible actions overall when the pressures and trade-offs that exist in what he calls 'real work' are considered. Moreover, an important factor for ensuring compliance with procedures is that the procedures are perceived to be practicable and meaningful for the bridge crew, or as Reason (2008, p. 58) phrased it, '*attitudes and beliefs leading to non-compliance are only half the problem. The other half, or more, arises from bad procedures.*'

Regarding the SA Level 2 errors, 'insufficient training' was identified as the most significant contributing cause. Because human working memory has a very limited capacity, we tend to rely on mental models that are stored in our long-term memory during the processing of information. Well-developed mental models are created from training and experience and can influence an operator's ability to achieve SA at all levels (Endsley, 1995b). In the current study, insufficient training was primarily associated with the SA Level 2 errors that were caused by 'lack of or incomplete mental models' related to the vessels' technical systems. In general, a fairly large proportion of the maritime training regime consists of on-board training in the sense that senior officers train the cadets and junior officers on board their vessels. However, it is notable in this context that a lack of equipment standardisation appears to be characteristic of the maritime industry. For example, different vessels of the same type in a shipping company's fleet can be equipped with devices from different manufacturers, and these differences can entail significant differences in man-machine interfaces. Autopilot can serve as a simple example. Attempts to steer a vessel manually when the autopilot is activated can have the following consequences: (a) no signals other than the autopilot button indicate that the autopilot is activated, (b) control is automatically transferred to manual steering after a few seconds, or (c) an alarm sounds to indicate that the autopilot is activated. This lack of standardisation means that retraining and practice are of the utmost importance whenever an officer is transferred to a different vessel (Grech et al., 2008). If such training and practice does not occur, the officer might work based on a simplified mental model and thereby be vulnerable to SA errors.

## 5. Conclusions

Several studies have reported that the loss of SA is a significant factor in incidents and accidents that are associated with human error (Endsley, 1995a; Grech et al., 2002; Jones and Endsley, 1996). In this respect, our findings confirm earlier research in that 18 of 21 cases associated with human error may involve the loss of SA. Our study further suggests that 'inadequate design', 'planning failure', 'communication failure', 'distracting elements' and 'insufficient training' may have been significant contributing factors to the incidents. These findings are perhaps not surprising because the avoidance of these factors is an important precondition for the safe operation of any system. However, this study demonstrated how these factors might have influenced the SA of the bridge crews during the courses of the events. In so doing, this study examined the contributing factors from the perspective of

the potential consequences on SA rather than as general weaknesses in the system. To our knowledge, no previous studies of accident reports have examined the roles of contributing factors related to the loss of SA in accidents and incidents.

Extensive SA-related research has been performed over several decades. However, whether these research efforts have actually led to improvements in the industry has been questioned (Salmon and Stanton, 2013). In this context, the present study will hopefully have practical implications for the petro-maritime industry because it identified some potential areas for improvement. Most notably, errors due to reduced vigilance and misconceptions of the technical automation systems emerged as the primary antecedents of collisions. In this context, Endsley (2012) recommended design principles that are believed to support SA in man-machine interactions. To create technological environments that support the SA needs of bridge crews, the industry should provide for design processes that are driven by SA theory in both new builds and modifications of existing vessels in the fleet. Overall, 'inadequate planning' was identified as the most common contributing cause. This finding is important because it might have direct practical implications for the shipping industry such as revising existing procedures for planning activities and/or ensuring that bridge crews comply with existing procedures. The current study also revealed that 'insufficient training' was the most common contributing cause associated with failure to comprehend or assess the situation at hand. Because well-developed mental models come from experience and training (Endsley, 1995b), it is of the utmost importance that shipping companies adopt procedures that ensure that sufficient on-board training is provided in addition to training on navigation simulators. Due to the lack of standardisation of technical equipment, these procedures should provide sufficient overlap periods and training whenever an officer is transferred to a new vessel in a shipping company's fleet.

## Acknowledgments

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*Special section paper*

## Distributed situation awareness in complex collaborative systems: A field study of bridge operations on platform supply vessels

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This study provides empirical data about shipboard practices in bridge operations on board a selection of platform supply vessels (PSVs). Using the theoretical concept of distributed situation awareness, the study examines how situation awareness (SA)-related information is distributed and coordinated at the bridge. This study thus favours a systems approach to studying SA, viewing it not as a phenomenon that solely happens in each individual's mind but rather as something that happens between individuals and the tools that they use in a collaborative system. Thus, this study adds to our understanding of SA as a distributed phenomenon. Data were collected in four field studies that lasted between 8 and 14 days on PSVs that operate on the Norwegian continental shelf and UK continental shelf. The study revealed pronounced variations in shipboard practices regarding how the bridge team attended to operational planning, communication procedures, and distracting/interrupting factors during operations. These findings shed new light on how SA might decrease in bridge teams during platform supply operations. The findings from this study emphasize the need to assess and establish shipboard practices that support the bridge teams' SA needs in day-to-day operations.

### Practitioner points

- Provides insights into how shipboard practices that are relevant to planning, communication and the occurrence of distracting/interrupting factors are realized in bridge operations.
- Notes possible areas for improvement to enhance distributed SA in bridge operations.

The oil and gas industry is dependent on services from the maritime industry for rig-moving operations, platform supply operations, and standby services, among other functions. Because of the potential for severe damage to human, environmental, and

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economic assets, collisions between attendant vessels<sup>1</sup> and offshore facilities are among the worst-case scenarios in the industry. On 8 June 2009, such an event occurred when the well-stimulation vessel *Big Orange XVIII* lost control and collided with an offshore facility on the Norwegian Continental Shelf at a speed of approximately 9.7 knots. Although the consequences were limited to financial losses, the Norwegian Petroleum Safety Authority considers this incident to have had a large hazard potential (Kvitrud, 2011). In general, collisions between attendant vessels and offshore facilities involve the risk of damage to substructure and hydrocarbon pipelines, with subsequent leakage and possible ignition and fire.<sup>2</sup> According to the investigators in the *Big Orange XVIII* case, the direct cause of the collision was the duty officer's assumption that the vessel was on manual steering when it was, in fact, on autopilot (Norwegian Petroleum Safety Authority, 2009). As a result, all attempts to steer the vessel manually failed, and the ensuing collision with the offshore facility was unavoidable.

From 2001 to 2010, 26 collisions between attendant vessels and offshore facilities on the Norwegian continental shelf were reported, and at least six are believed to have had catastrophic potential (Kvitrud, 2011). These six cases were analysed in two earlier studies that sought to identify common contributing factors. Oltedal (2012) found that human errors in detecting or interpreting a technical state or error were the direct cause in four of the six cases. These findings are in agreement with the conclusions of Kvitrud (2011), who identified poor understanding of and training in advanced technical equipment as important underlying factors. A recent study of 23 available accident reports from 2001 to 2011 concerning collisions between attendant vessels and offshore installations on the Norwegian continental shelf suggests that 18 of 23 collisions were caused, at least in part, by the bridge teams' loss of situation awareness (SA) (Sandhåland, Oltedal, & Eid, 2015). SA was then defined as 'awareness of what is happening around you and understanding what that information means to you now and in the future' (Endsley, 2012, p. 13). Another notable finding of the Sandhåland *et al.*'s (2015) study was that planning failure was an antecedent to loss of SA in 10 of these 18 cases. A typical example of planning failure was inadequate use of available checklists prior to the operation, which in turn caused a lack of awareness regarding the vessels' technical status. The study also identified communication failure as an antecedent to loss of SA in seven of the 18 cases. An example of a communication failure is the inadequate transfer of command at the bridge or the failure to transfer critical information during shift handover. Finally, distracting/interrupting elements were identified as antecedents to loss of SA in six of the 18 cases, for example the need to perform administrative tasks that drew attention away from the navigational equipment or surrounding environment.

The bridge on a ship represents a complex collaborative system in which highly specialized individuals operate navigational equipment and interact to perform safety-critical operations. Following from a systems ergonomics perspective, the bridge is a prototypical example of a system in which performance is closely dependant on interaction with and efficient use of tools, such as steering documents, checklists, and

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<sup>1</sup> This term refers to vessels that provide services to offshore installations, such as platform supply vessels (PSVs), anchor-handling vessels, standby vessels, and oil tankers. Historical data indicate that 98% of collisions between vessels and offshore facilities on the Norwegian continental shelf involve attendant vessels (The North West European Area Guidelines, 2009).

<sup>2</sup> See Daley (2013) for a description of the Mumbai High North accident, in which a multipurpose supply vessel lost control and hit several marine risers on an offshore facility on the west coast of India. The collision caused a gas leak, which ignited and caused 22 fatalities.

technology. According to Stanton, Salmon, Walker, and Jenkins (2010), distributed situation awareness (DSA) is a salient characteristic of complex collaborative systems that can be defined as 'activated knowledge for a specific task within a system at a specific time by specific agents' (p. 34). Following from this perspective, it is important to examine interactions between agents (human and non-human actors), including interactions between individuals and interactions between individuals and tools, to describe how SA information is distributed and coordinated within the system (Salmon, Stanton, Walker, & Jenkins, 2009). In this study, we draw on the concept of DSA and extend the findings of the Sandhåland *et al.* (2015) study, which indicated that inadequate planning, communication failure, and interrupting/distracting elements are important antecedents to loss of SA. In particular, we wanted to increase our understanding of how interactions between agents in bridge operations on board a selection of PSVs are reflected in established practices related to planning, communication, and management of distracting/interrupting elements, and in turn, how shipboard practices affect the bridge teams' SA needs.

Previous research has relied heavily on accident analysis to understand the complex individual and contextual factors that increase the likelihood of accidents in the maritime industry; however, accident analysis might overemphasize the unique and salient aspects of the situation because of distortion, self-serving bias, and decay of information over time (Macrae, 2009). In this study, we chose an ethnographic, true-to-life approach, sampling and assessing everyday situations on board a selection of PSVs.

Because a significant proportion of the work on board a PSV happens near offshore facilities, there is a risk of collisions with these facilities. For that reason, we put particular emphasis on shipboard practices related to safe approach and positioning of the vessels alongside the offshore facilities. We were especially interested in observing the planning and execution of operations alongside offshore facilities, the communication between bridge team members, and potentially distracting/interrupting elements that could have implications for the bridge teams' SA.

Moreover, although the bridge teams' SA could be influenced by factors independent of the bridge (e.g., if the team made decisions during coffee breaks or off-duty periods), our study was limited to practices at the bridge.

## **Theoretical foundation**

### *Theories of SA*

The concept of SA has been debated, and different approaches to studying SA have been suggested. From a psychological perspective, SA is understood as cognitive processes in the minds of individuals in a system. From a systems ergonomics perspective, SA is understood as a process that happens through interactions between individuals and the tools that they use to accomplish their goals (Stanton *et al.*, 2010). These two approaches to studying SA are further detailed below.

Within the psychological tradition, the most cited model of SA is Endsley's (1995) three-level model. She suggested that an individual builds SA at three different levels. First (SA level 1), the operator perceives critical information that is relevant to his or her goals. In the context of safe navigation, this information may include factors such as the vessel's operational status, the vessel's positioning, and other approaching vessels. Second (SA level 2), the operator will integrate and evaluate the information at hand. She or he has to understand the perceived information in relation to relevant goals and objectives, such as safe approach to an offshore facility. Third (SA level 3), the operator uses his or her

perception and comprehension of the situation to forecast and estimate likely imminent outcomes, opportunities, or threats. For instance, by calculating speed, currents, and wind, the duty officer can avoid colliding with the offshore facility by taking manual control or reprogramming the automatic navigation systems.

Following from Endsley's three-level model, studies of SA involve examining the cognitive processes in each individual's mind. In contrast, the concept of DSA favours a system ergonomic approach to studying SA by considering the physical or social environment in which these cognitive processes occur. In accordance with the concept of *distributed cognition* (Hutchins, 1995), a central assumption in DSA is that SA information is held by different agents that comprise a collaborative system. An intriguing implication of conceptualizing SA as distributed cognition is that SA information is not only distributed within the team but also in the tools that they use to accomplish their goals (Salmon *et al.*, 2009; Stanton *et al.*, 2006). At the bridge on board a PSV, several tools provide the bridge team members with SA information including radar equipment, anemometers, wave riders, current and tide tables, weather forecasts, and steering documents. Following from this conceptualization, Stanton *et al.* (2006) proposed that DSA is a product of coordination among these agents such that the system itself holds the SA that is required to accomplish its goals. It is thus critical that the right information is transferred to the right team member at the right time in order for each individual to achieve and maintain the SA necessary for their function in the system (Stanton *et al.*, 2010). Thus, in contrast to the psychological approach to SA, a DSA approach views SA as a system property 'by consideration of the information held by the artefacts and people and the way in which they interact' (Stanton *et al.*, 2010, p. 34).

In maritime bridge operations, safe navigation and execution of cargo operations are the result of a team effort rather than the work of an isolated individual. From a psychological perspective, the concept of team SA, which is defined as 'the degree to which every team member possesses the SA required for his or her responsibility' (Endsley, 1999, p. 270), recognizes the different SA needs and requirements that are associated with different roles in a team. However, according to Endsley (2012), the degree of SA shared among the members in the team should be high. Although it may be intuitively appealing, the concept of shared SA is problematic because unique personal preferences, schemata, skills, and training influence each team member's perception of the situation. In response to these inherent difficulties, proponents of a DSA perspective have suggested that different team members have different roles and therefore need to comprehend and use information differently (Stanton *et al.*, 2010). It is further emphasized that the agents that comprise a collaborative system may have different but potentially compatible SA, depending on the role of each agent in the system (Stanton *et al.*, 2006).

A DSA approach to examining SA in collaborative systems does not imply that psychological approaches to studying SA are redundant; rather, DSA approaches provide an alternative and complementary view of SA in collaborative systems (Salmon *et al.*, 2008). We have adopted a DSA approach because this perspective captures more of the human-system interaction in complex operational systems such as PSVs. We also believe that this approach will enhance our understanding of the factors that influence the bridge team members' SA. The DSA perspective will further point to the potential value of using an ethnographic, process-oriented approach to investigate SA in complex collaborative systems.

### *Antecedents to SA*

Previous research has identified factors that are believed to affect SA in operational settings. For instance, Sneddon, Mearns, and Flin (2013) found that stress, sleep disruption, and fatigue were associated with lower levels of work SA in a study of offshore drill crews. Endsley (2001, 2012) proposed that both system design (availability of information) and interface design (how information is presented) are important in SA. Factors such as training, knowledge, and skills are also important in regard to the bridge team's achievement and maintenance of SA in operational settings (Endsley, 1995; Espevik, Johnsen, & Eid, 2011). Planning activities, communication, and distracting/interrupting elements have also been suggested to influence SA. In the following sections, we will elaborate on these themes.

*Planning.* High-quality planning prior to performance of a task can reduce the risk of loss of SA because it can increase bridge teams' awareness of the risks that are associated with an upcoming task (Flin, O'Connor, & Crichton, 2008). If critical information provided by other agents is missed or misperceived, this miscommunication could lead to loss of SA and severe consequences. It is therefore particularly important that the bridge team pay close attention to planning. In particular, contingency planning – anticipating possible scenarios and threats – may contribute to consolidating and developing schemata and structural aspects of social tasks. Insofar as planning provides shared knowledge about the system, possible threats, and strategies, it may increase the likelihood of the bridge team achieving an SA that will facilitate individual and collective task performance (Mohammed, Ferzandi, & Hamilton, 2010).

*Communication.* In our observations of bridge teams at work, our point of departure was that interactions such as information sharing and interaction with technological equipment or the environment are vital for optimal system performance (Bolstad, Cuevas, Gonzalez, & Schenider, 2005). A notable aspect of this dependence is that communication failure is often reported to precede loss of SA because communication is commonly considered to be a key factor in connecting and maintaining the different parts of a distributed system (Stanton *et al.*, 2010). In analysing team communication, it might be helpful to distinguish between *information exchange* and *communication* to understand how practices can affect bridge teams' information needs. Thus, *information exchange* refers to the type of information that is transferred between the bridge team members. The transmission of critical information, such as the location of nearby vessels and the transfer of command during shift handover, is relevant for safe navigation. In contrast, *communication* refers to how the information is transferred between the bridge team members. Communication should involve the use of succinct and accurate terminology without circuitous language (Smith-Jentsch, Johnston, & Payne, 1998). In addition, it is critical to ensure that the information is understood. To this end, closed-loop communication, in which the receiver repeats the information and the sender confirms it, may be an effective technique (Bowers, Jentsch, Salas, & Braun, 1998).

*Distracting/interrupting elements.* Direct attention is necessary to perceive and understand received information (Endsley, 1995). Thus, the bridge team members' ability to sustain attention is a critical dimension. In operational settings, the flow of information

between agents can be complex and dynamic, which makes operators vulnerable to distractions and interruptions (Endsley & Robertson, 2000; Flin *et al.*, 2008; Robertson & Endsley, 1995). Distracting and interrupting elements can stem from various sources, such as incoming telephone calls or other crew members, and they increase the strain on limited attention resources (Loukopoulos, Dismukes, & Barshi, 2009).

### **System description**

In addition to national regulations, international conventions, and shipping companies' safety systems, the North West European Area (NWEA) guidelines for the safe management of offshore supply and anchor-handling operations<sup>3</sup> provide structured recommendations to assist bridge teams in their day-to-day operations. The NWEA guidelines were developed as a joint project between maritime and offshore organizations in Denmark, the Netherlands, the UK, and Norway to incorporate best practices in offshore supply and anchor-handling operations in the industry (The North West European Area Guidelines, 2009). Although the guidelines have the status of recommendations, vessels that provide supply services to the offshore industry must comply with the guidelines according to client requirements. The NWEA guidelines note possible dangers, encourage vigilance, and prescribe a systematic, data-driven approach to safe navigation. In effect, the guidelines shape the bridge teams' assessment and comprehension of situations and prescribe best practices. Therefore, the NWEA guidelines constitute a common framework for establishing SA during offshore operations.

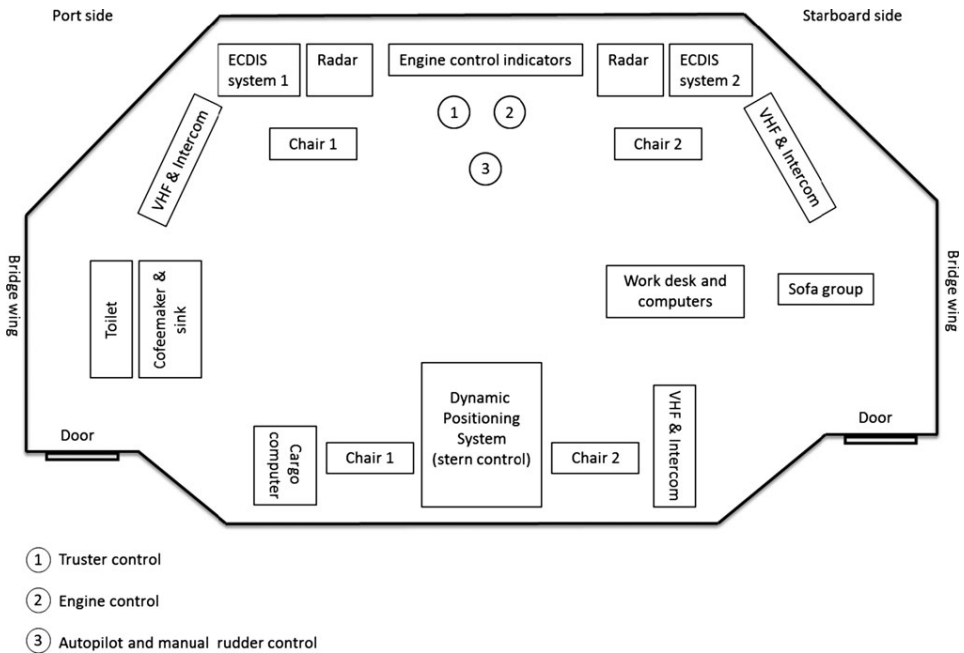
The bridge team on board a PSV usually consists of four officers divided into two shifts. The chief officer and the master are usually on separate shifts and are paired with an officer of lower rank. In addition, cadets are occasionally added to the bridge team for training purposes. The offshore facilities are protected by a safety zone with a radius of 500 metres, and access to the offshore facilities requires permission from the offshore facility's control room. Whenever the vessels operate inside the safety zones, the NWEA guidelines mandate that the bridge be manned with two officers or, alternatively, one officer and a cadet with a bridge-watch certificate; however, sailing between port and the offshore facilities is frequently performed with a single officer present on the bridge. Before the vessels are given permission to enter the offshore facilities' safety zones, the bridge teams must confirm that mandatory checklists have been completed. These checklists concern the vessel's technical status, assessment of weather conditions and communication lines, and other items. According to the NWEA guidelines, loading/offloading operations alongside the offshore facilities should, to the greatest extent possible, be performed on the leeward side to ensure that if a vessel experiences any technical problems, it will be in a drift-off position and thus avoid colliding with the offshore facility.

The bridge team on board a PSV employs a variety of tools to navigate safely, but the vessels included in our study had different bridge arrangements regarding the placement of tools and the interior of the bridge. Figure 1 depicts a typical bridge.

Loading/offloading operations alongside the offshore facilities are performed from the stern steering position and usually through dynamic positioning (DP). DP is an advanced automated manoeuvring system that is based on positioning reference systems such as global positioning systems. The DP system requires minimal intervention by the bridge

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<sup>3</sup> The NWEA guidelines were replaced by *Guidelines for Offshore and Marine Operations (GOMO)* on 1 June 2014. However, the NWEA guidelines remained in effect at the time this study was conducted.



**Figure 1.** Sketch of a typical bridge on board a platform supply vessels (PSV).

team to keep the vessel in a fixed position; the main task for the bridge team is to monitor the technical system and surrounding environment and take action as needed. During loading/offloading operations, both officers were positioned at the stern steering position. The normal division of responsibility is that the DP operator is responsible for navigational activities, whereas the other officer is responsible for the loading/offloading operation, communication with other actors, and supporting the DP operators that are engaged in monitoring. Sailing back and forth between port and offshore facilities, in addition to between offshore facilities, was usually performed using autopilot from the forward steering position. All of the vessels used the Electronic Chart Display and Information System as an alternative to paper nautical charts. In addition to electronic chart information, the system integrates information that is provided by an automatic identification system, such as other vessels' positions, heading, and speed, and generates alarms when the vessel faces a risk, such as a collision with another vessel. The vessels were also equipped with radar systems that use radio waves to detect objects in the fairway. In addition, available control panels provided various indicators related to the vessels' technical systems, such as engine-control indicators.

## Method

### *A theory-driven ethnographic approach*

A critical challenge in ethnographic studies is the choice of a focus because the researcher simply cannot observe everything. A theoretical proposal is needed to guide data collection (Willis & Trondman, 2002; Yin, 2009). In this respect, this study builds on concepts at several levels of abstraction. First, the concept of DSA allows us to examine practices to describe how SA information is distributed and coordinated on the bridge.

Second, the selected themes (i.e., planning, communication, and management of distracting/interrupting elements) connect to DSA in that they refer to interactions among agents that comprise the system. These activities are also believed to influence the bridge team's ability to achieve and maintain SA. Finally, this study required more accurate concepts within each theme, which we termed 'observable practices' (e.g., planning of the approach to the offshore facility, communication related to the transfer of command, and conduction of administrative tasks during navigational activities), to focus on situations that are relevant to the PSV setting. In this process, we drew on findings from previous studies of collisions between attendant vessels and offshore facilities (Kvitrud, 2011; Oltedal, 2012; Sandhåland *et al.*, 2015), along with information derived from a preparatory field trip on board a PSV and informal conversations with navigators. Concepts were selected based on previous research and the informed opinions of practitioners regarding critical components of safe navigation on board a PSV. Together, these concepts served as a framework that gave the study direction.

### **Sample descriptions**

The fieldwork was conducted on board four PSVs that belong to two Norwegian-controlled shipping companies. Both shipping companies were selected based on their extensive experience in providing supply services to the oil and gas industry. PSVs were chosen because they are the type of vessel that most frequently approaches offshore facilities. The vessels included in the study were state-of-the-art PSVs built between 2003 and 2012. With some variations, a typical vessel was 90 m long and 20 m wide and carried 5000 tonnes of deadweight tonnage. The crew members had private cabins and shared off-duty recreational facilities, such as fitness equipment, television, and internet facilities. The rotation arrangement was 4 weeks at work and 4 weeks off on all of the vessels. All of the vessels were on long-term charters to three different oil companies. Two of the vessels operated on the Norwegian continental shelf, and the remaining two operated on the UK continental shelf. Apart from some vessel-specific adjustments to the checklists, both shipping companies had to follow the NWEA operational guidelines. All four vessels aimed to supply the offshore facilities in an efficient and safe manner.

A total of 18 bridge team members (15 officers and three cadets) from eight shifts were included in this study. All participants spoke Norwegian fluently and, except for one participant, all had trained at Norwegian educational institutions.

### **Data collection**

Each fieldwork period lasted for between 8 and 14 days, with an average attendance on the bridge of approximately 10 hr a day. Approximately 450 hr of observational data were collected for the study. The fieldwork was conducted over a 1-year period from October 2012 to October 2013.

To minimize disturbance to the operations performed at the bridge, only one researcher worked on board the vessels. The researcher who conducted the field work has a theoretical background in risk and safety management and has also worked with safety issues in the oil and gas industry.

Several studies have highlighted the importance of trust and cooperation for the collection of accurate and dependable data in fieldwork (Aase & Fossåskaret, 2007; DeWalt & DeWalt, 2011; Fangen, 2005). In this respect, a role that was consistent with Gold's (1958) 'participant-as-observer' was adopted. That is, the researcher followed the crew in



their day-to-day activities and spent more time participating and interacting with the crew members than observing from a distance. In practice, this involved informal conversations and asking questions when the crew members were available. In addition, the researcher observed how the bridge team members interacted with each other and with other entities to gain first-hand experience of naturally occurring events and some familiarity with the underlying operational procedures. The bridge teams also demonstrated how the equipment on the bridge (e.g., the DP system and position reference systems) worked, thereby providing the opportunity to further elaborate on technical information that emerged during conversations and observations. The researcher also asked questions related to observations. For instance, when the bridge team positioned the vessel alongside the offshore facility without any prior overt discussion, the researcher might have asked 'What type of assessment did you do when you made this particular approach?'

Some theorists have suggested that writing field notes in view of the informants might strain relationships with the researcher and distract the researcher in the field (Emerson, Fretz, & Shaw, 1995; Fangen, 2005). Field notes were therefore written in between the observation periods. The researcher withdrew to the cabin several times a day or immediately after significant events to record observations. Observations and quotations presented in this study are excerpts from the researcher's field notes. Thus, the reader should be aware that observations and quotations are as remembered by the researcher.

### ***Processing and presentation of results***

Initially, observations and quotations were systematized according to the concepts in the framework. We thereby used a 'provisional coding' method, in which codes were generated from investigations performed prior to the fieldwork (Saldaña, 2009). Thereafter, the data were re-examined, and the initial categories were refined. Finally, the data were re-examined to identify similarities and differences between vessels. The coding of the field notes was performed by the first author, who also performed the field work. The findings were discussed with experts in navigation and safety sciences throughout the coding process.

The representational style of this study might, according to Van Maanen's (2011) classification of voices of the field, be characterized as a 'realist tale'. We present our findings as concrete images of shipboard practices on the bridge that are related to planning, communication, and management of distracting/interacting elements. The researcher's experience in the field is not highlighted; rather, the story that we tell conveys concrete descriptions of what the bridge teams do and say and is organized according to our selected themes and observable practices.

Each vessel and informant was assigned a code to identify their observations and quotations. The vessels are coded V1, V2, V3, and V4; officers are given the codes O1, O2, O3, and O4; and cadets are given the codes C1 and C2, which are in turn linked to their vessel (e.g., V1-O3 and V3-C1). Occasionally, it was necessary to refer to a particular shift; shifts are coded as S1 or S2 and similarly linked to the vessel (e.g., V1-S1).

### ***Methodological challenges***

We hope that the above chapter convinces the reader that ethnography is a useful methodological approach in this context; however, all methodological approaches have limitations. In this section, we will concentrate on the major limitations that we believe influenced our findings. First, the relationship between the researcher and the bridge

team may have influenced the findings in several ways. Structurally, the researcher inhabited an 'unknown' position in that all bridge team members had clear rights and duties in relation to each other, but the researcher was an outsider with no clear rights and duties in relation to the vessel. This position may have caused some uncertainty both about the researcher's role on board the vessel and the aims of the study. Additionally, the researcher's presence may have influenced the bridge team's behaviour. Statements such as 'I have to say, you do the checklists thoroughly when she [the researcher] is present' (V4-O3) suggest that the researcher's presence promoted increased use of checklists and other steering documentation. Second, the researcher's lack of a nautical background is important in terms of the researcher's understanding of the system. In a high-tech expert-run system, such as a PSV, outsiders are unlikely to be able to fully understand the ongoing processes. The use of highly specialized terminology and tacit agreements among the bridge team members may also have impeded the researcher's understanding.

## **Results**

In the following sections, we describe how shipboard practices related to planning, communication, and management of distracting elements were realized in day-to-day operations. Regarding planning activities, we focus on planning of the approach to the offshore facility and contingency planning related to operations alongside the offshore facility. In regard to communication practices, we focus on communication between bridge team members during completion of checklists, transfer of command, DP operations, and changes in the vessel's manoeuvring position. Finally, distracting and interrupting elements are examined in terms of interference with administrative tasks, use of electronic devices, and non-essential conversations.

### ***Planning practices***

The NWEA guidelines underscore the importance of the planning phase before vessels enter an offshore facility's safety zone (The North West European Area Guidelines, 2009). In this phase of the voyage, the bridge team uses a variety of information provided by assorted agents to make a safe approach and position the vessel alongside the offshore facility. This information includes, but is not limited to, information about environmental forces provided by tools (e.g., anemometers, wave riders, current and tide tables, and weather forecasts), information provided by the offshore facility regarding operational conditions on board the offshore facility (e.g., positioning and range of cranes, potential anchor chains, heading, and flaring), and information provided by the technical equipment on board the vessel regarding the vessel's technical status and loading plans regarding the positioning of cargo on deck. The following sections present observations and quotations to illustrate findings that relate to pre-entry safety planning, including contingency planning.

#### ***Planning of approach***

On one of the vessels (V2), the senior officer on both shifts initiated active discussions about how to approach and position the vessel alongside the offshore facilities. The following narrative describes a conversation between a senior officer and his junior officer prior to approaching the offshore facility and positioning the vessel:

A senior officer and his junior officer have different suggestions about how to approach and position the vessel alongside the offshore facility. The senior officer asks the junior officer to state the arguments for his viewpoint. Subsequently, the senior officer suggests a different solution and adds that they have always performed it like that. The junior officer then replies 'I don't care if you have performed it like that for the last 100 years, there may be better solutions', to which the senior officer replies 'You're right. Let's do it your way.' After a while, once the vessel is well positioned alongside the facility, the senior officer comments, 'It was a good idea to position it like this.' (V2-O1 and V2-O3)

In the situation outlined above, different solutions for how to approach and position the vessel are proposed. On the remaining three vessels (V1, V3, V4), planning practices varied; however, planning for the approach and positioning very often took the form of a brief exchange and tacit agreement among the bridge team members, as follows: Officer V3-O1: 'Which side do they [the offshore facility] prefer?' and Officer V3-O3: 'The east side.' Little additional verbal communication occurred among the bridge team members, thereby implying that these assessments and the subsequent decision regarding the situation occurred in each individual's mind, without explicit communication about procedures. The differences in planning practices among the vessels seem to be associated with shipboard leadership and the associated training philosophy. The senior officers on board the vessel that held overt discussions frequently encouraged the junior officers and cadets to express their viewpoints, as supported by an observation in which one senior officer listened to the discussion between a junior officer and his cadet regarding how to approach and position the vessel. The senior officer did not interfere in the discussion before they finished; afterwards, he asked them to state the arguments in support of their decision. Based on the ensuing discussion, the initial plan was adjusted (V2-O2, V2-O4, and V2-C1).

### *Contingency planning*

Although all known risk factors were considered and the vessel was well positioned, unforeseen events such as technical failures remain possible. Several of our informants expressed concerns about this possibility:

As a DP operator, I constantly think about what might go wrong and what to do if anything should happen (. . .) we often talk about how important it is to think through what might happen and how to address the situation if the worst-case scenarios should ever materialise. (V1-O1)

No explicit discussions of such scenarios were witnessed, thus indicating that contingency planning was primarily performed as an individual activity rather than as a team activity on board the vessels; however, one of the participants had a different opinion:

It is not possible to keep in mind what could go wrong at all times—then it is impossible to work. If, for example, we have positioned the vessel on the weather side, wind limitations are within requirements and you have enough engine power, then you just have to rely on your equipment—living is dangerous as well. If we are positioned on the downwind side, then there is nothing to worry about anyhow. (V3-O2)

This quotation indicates that there are other views regarding the value of contingency planning.

### **Communication practices**

Operations on board a PSV require interaction among various agents, both on board the vessel and on the offshore facility. For the bridge team to gain access to safety-critical information, it is important that the information is communicated in a clear and unambiguous manner. The overall picture shows great variation in communication practices on board the vessels. In the following section, we provide examples of communication related to the completion of checklists, transfer of command, and DP operations alongside offshore facilities, including switching between the vessel's manoeuvring positions.

#### *Completion of checklists*

The bridge teams have mandatory checklists that are available during the planning of an approach that can support their awareness of critical information before the vessel enters the safety zone. The pre-entry checklist has checkpoints for the vessel's operational status, communication lines with the offshore facility and other departments on board, and weather conditions, among other items. If the vessel is preparing for DP operations, an additional checklist that pertains to the operational status of the DP and its backup systems must also be completed. However, communication among the bridge team members during the completion of checklists varied considerably between vessels. On one vessel (V1), Officer A cited the items in the checklists, whereas both Officer A and Officer B checked the system independently and reported on the items. On another vessel (V2), Officer A cited items in the checklist, whereas Officer B checked the system and reported back to Officer A. On the two remaining vessels (V3 and V4), the method for completion of the checklists depended on the officer on duty. The general rule on these vessels was that the checklists were performed by a single officer, either without any communication with the other officer or with two-way communication about some of the items. The following is an example of the latter:

The vessel is heading towards the offshore facility's safety zone, and the cadet is completing the 500-metre pre-entry checklist. He is reading some of the items aloud, and the officers reply with a yes or no. When he reads the item 'autopilot off', the two other officers both reply 'not yet.' The cadet continues with the rest of the items. Meanwhile, there is a shift handover and, as part of the handover, the cadet informs the oncoming shift that 'the 500-metre checklist is completed, everything OK'. (V3-S1)

No further information regarding the status of the autopilot was exchanged. In addition to providing an example of how the checklists were completed on board the vessel, this situation also demonstrates that the checklist was started and completed by the bridge team that was going off shift rather than the shift responsible for the approach and positioning alongside the offshore facility.

Some participants, especially the less experienced officers, stated that they regarded the checklists as useful tools, whereas others emphasized that they would complete the listed tasks with or without the checklists. Checklist activities were occasionally completed by memory, independent of the paper copy and without communication with other bridge team members.

*Transfer of command*

Everyone must have a clear understanding of which officer is in command of the vessel at any given moment. To this end, transfers of command must be made explicitly. Such transfers occur both between shifts and during the shift. During shift handovers, the transfer of command was, as far as it was observed on all the vessels, performed using the statements 'good watch' and 'good watch below'. This was performed after necessary operational and safety-critical information had been given to the oncoming shift; however, explicit communication is important when command is transferred between and within shifts. For instance, on two of the vessels (V1 and V2), both the chief officers and the masters frequently approached the bridge even when they were off duty. Although there seemed to be a common understanding regarding who was in command, their interactions with the duty officer on watch appeared to create situations with a potential for confusion. The following passage describes a situation on board one of the vessels:

The vessel is on autopilot heading towards port. The officer on watch leaves the control stand in order to make coffee and perform some minor routine tasks. The master of the vessel, who has already entered the bridge, positions himself by the control stand. No explicit information exchange about the command of the vessel or about the vessel's operational status occurs. When the officer on watch finishes his duties, he joins the master at the control stand, where they both remain for a while—until the master leaves the bridge. (V1-O1 and V1-O4)

In the situation outlined above, command issues seem to be based on tacit agreement rather than a clear and unambiguous transfer of command. In addition, no information regarding the voyage was exchanged before the officer on watch left the control stand.

*DP operations and changes in the vessel's manoeuvring position*

During DP operations alongside the offshore facilities, misperceptions and misunderstandings may have serious consequences. In such operations, the responsibilities of the officers are normally predefined such that one is responsible for the DP operation, whereas the other is responsible for loading/offloading, communication with other parties, and support for the DP operator's monitoring responsibilities. Because the vessels are equipped with two DP stations, both officers have access to navigational equipment and communication devices. On most of the observed shifts (V1-S1, V2-S1, V2-S2, V3-S1, V4-S2), the predefined division of responsibility seemed to be followed; however, on three shifts (V1-S2, V3-S2, V4-S1), frequent deviations from the predefined division of responsibility were observed. Observations from two of the shifts (V1-S2 and V4-S1) are relevant to communication because they indicate that the officer responsible for loading/offloading sporadically acknowledged pre-warnings on the DP system that indicated that the vessel's location deviated from the DP set point. Such warnings are indicated not by an audible alarm but rather by text and a colour code on the DP screen. In these cases, the pre-warnings were acknowledged without communication of the action to the DP operator.

When vessels operate on DP, their steering mode is transferred from the forward manoeuvring station to the DP station that is positioned aft. Thus, changes in the vessel's manoeuvring position can represent a risk (The North West European Area Guidelines, 2009). Until the transfer and takeover of command are acknowledged from the other steering position, the bridge team is not in control of the vessel's movements. On two of

the vessels (V3 and V4), this operation was primarily performed by a single officer, thereby making communication irrelevant. On the remaining two vessels (V1 and V2), the transfer of the manoeuvring position was performed by two officers – One at the forward manoeuvring station and the other at the aft manoeuvring station. On these vessels, the transfers were, as a general rule, performed using a standardized communication procedure: ‘All controls set to neutral position—are you ready?’ and ‘All controls set to neutral position—I am ready.’ With only minor changes in the wording, this communication was consistent on one of the vessels (V2). On the other vessel (V1), the bridge team occasionally deviated from this standardized communication. The following passage describes one of those situations:

The vessel has completed its loading/offloading operation and is about to exit the offshore facility 500-metre safety zone. The following describes the communication during transfer of manoeuvring control: Officer A, who is positioned aft, asks: ‘Do you want her?’ whereupon Officer B at the forward position answers: ‘Yes.’ A few seconds after transfer of control, Officer A mumbles, ‘There is something wrong here’, and at the same time, Officer B shouts, ‘Deactivate the thrusters!’ Officer A then replies, ‘I cannot do it.’ Subsequently, Officer B joins Officer A at the aft position and, within a few seconds, they have sorted out the problem. (V1-O1 and V1-O2)

It turned out that their problems were caused by the controls, which were not set in the neutral position; this, in turn, caused unexpected movements. It is reasonable to assume that the use of standardized communication would have created greater awareness regarding the status of the technical system.

### ***Interruptions and distractions***

Most professionals manage interruptions and distractions on a daily basis, and bridge teams on board PSVs are no exception. In addition to navigation, the bridge teams have to manage radio communication and incoming telephone calls, among other things. Although interruptions and distractions are an essential part of bridge operations, their potential negative consequences for safe navigation should not be ignored. We focused on interrupting and distracting elements that originate from ‘non-task-related’ factors, that is factors that were not related to an ongoing operation. The most prominent factors were related to concurrent task management, such as administrative tasks, the use of electronic devices, and informal, non-essential conversations. We will elaborate on these findings in the following sections.

#### *Administrative tasks*

Some participants stated that the number of administrative tasks did not influence their ability to attend to navigational activities because there was a sensible allocation of tasks among the bridge team members; this claim was also supported by observations. However, other participants indicated that the number of administrative tasks on board the vessel challenged their ability to fulfil their navigational responsibilities. The following passage describes one of those situations:

One of the officers is alone on the bridge, and the vessel is on autopilot heading towards port. Located in the administrative area of the bridge, the officer is busy updating maritime documents. In that position, he had a limited view of both the control stand and the

surrounding environment. According to the officer, 'I have to do this when we are sailing because I don't have time to do it in port; on the other hand, when we are sailing, I am supposed to navigate. If we get audits, they won't let us leave until it [the paperwork] is done. Now I am two weeks behind and have to finish before we reach port.' (V1-O4)

In the situation outlined above, no one was paying attention to the technical system or the fairway for a long period of time, which was not typical. However, other participants also expressed concerns about the number of administrative tasks in relation to their ability to perform navigational tasks:

When we are leaving port, we are far at sea before we have finished the paperwork. We are supposed to finish before we leave port, but that is not the case. I would have preferred that he [the second watch officer] was looking out of the windows instead of doing paperwork. (V3-O1)

In the statement above, the informant is suggesting that the intended organizational redundancy of manning the bridge with two persons is decreased because of administrative requirements during a demanding phase of the voyage.

#### *Electronic devices*

Other disturbing elements, such as the use of private mobile phones and personal computers, could also be characterized as distracting elements in this context. Major differences were observed both among the vessels and between shifts on each vessel, ranging from few or no observations on many of the shifts (V1-S1, V1-S2, V2-S1, V2-S2, and V3-S1) to the extensive use of such devices by some shifts (V3-S2, V4-S1, and V4-S2). The use of electronic devices on the bridge seems to be associated with age: It mainly involved the youngest crew members. It also seems to be associated with shipboard leadership, because minutes from HSE (Health, Safety and Environment) meetings indicate that the use of such devices had previously been an issue on board a vessel (V1) on which no such observations were made in this study. The minutes stated that the use of personal electronic devices was prohibited on the bridge.

#### *Non-essential conversations*

To maintain attention during periods of low workload, conversation might be necessary; however, conversations could distract from the bridge team's monitoring tasks. The following passage describes the context of a conversation that took place on one of the vessels:

The vessel is positioned for its loading/offloading operation in close proximity to the offshore facility. The officer whose responsibility it is to operate the DP system is conversing about personal issues with another crew member who is off duty. The upper part of the DP operator's body is turned towards the other crew member (sideways in relation to the DP station), and he (presumably) switches his attention back and forth between the DP station, the surroundings and his off-duty colleague. (V1-O2)

Does this conversation distract from the DP operator's monitoring tasks? According to one of the vessel's officers, it does not:

At the same time, the researcher and another officer are conversing on a topic related to technology and attention demands [on another part of the bridge]. During the conversation, the officer says, 'It takes a lot experience to converse like he is doing [points towards the DP operator] and still be able to operate the DP.' (V1-O1)

In the situation outlined above, the officer emphasizes the importance of experience for the ability to manage multiple tasks. Similar situations were observed on the other vessels. In general, access to the bridge does not seem to be restricted, thereby increasing the risk of distractions and interruptions by other crew members.

### Summary of findings

This study presents new empirical information about how shipboard practices regarding planning, communication, and management of interrupting/distracting elements are realized in real-world settings on board four selected PSVs. Several practices highlighted in our study were observed in all of the vessels: Contingency planning as an individual activity, distractions/interruptions due to non-essential conversations, and limited use of standardized communication during transfer of command. It is worth noting that the two vessels that practised two-way communication when completing the checklists had limited or no use of personal electronic devices on the bridge and practised standardized communication during the transfer of the steering position belonged to the same shipping company.

In the following sections, we will discuss the findings summarized in Table 1 in the light of the theoretical concept of DSA.

## Discussion

### Planning practices

Prior to the decision of how to approach and position the vessel alongside the offshore facility, information has to be collected from agents in the system, including anemometers, wave riders, current and tide tables, and weather forecasts. This information is

**Table 1.** Summary of findings

Themes	Observable practices
Planning	Planning of approach as an individual activity: V1 (*), V2 (-), V3 (*), V4 (*) Contingency planning as an individual activity: V1 (+), V2 (+), V3 (+), V4 (+)
Communication	Completion of checklists as an individual activity: V1 (-), V2 (-), V3 (*), V4 (*) Limited use of standardized communication during transfer of command: V1 (+), V2 (+), V3 (+), V4 (+) Inadequate transfer of information during DP operations: V1 (*), V2 (-), V3 (-), V4 (*) Limited use of standardized communication during transfer of manoeuvring position: V1 (*), V2 (-), V3 (+), V4 (+)
Distractions and interruptions	Administrative tasks: V1 (*), V2 (-), V3 (+), V4 (+) Electronic devices: V1 (*), V2 (-), V3 (+), V4 (+) Non-essential conversations: V1 (+), V2 (+), V3 (+), V4 (+)

Note. (+), could find; (\*), found a tendency; (-), could not find.  
DP, dynamic positioning.



crucial for the bridge team's ability to choose the safest strategy. This study revealed notable differences in planning practices, ranging from overt discussions to an implicit agreement among the bridge team members. Because SA information is held by different team members, they must share information to achieve an adequate understanding of the situation. There are thus some compelling arguments in favour of planning as a team activity. First, it is a reasonable assumption that planning as a team activity facilitates exchange of information that is relevant to SA. Second, because each team member has a different perspective on the world, they have to interact to help each other in making sense of their perspectives including how wind, waves, and currents, in combination with the vessel's technical status, will affect the vessel. Through collaboration, they can construct a more complete understanding of the situation than would be available to any individual alone (Weick, 2005). In other words, planning as a team activity may bolster safety by increasing the likelihood of relevant information being transferred and properly assessed by the bridge team prior to the operation.

Whenever the vessel is positioned alongside the offshore facilities, there is limited time to act if something unforeseen should occur. Technical faults, loss of signals to the positioning reference systems, and sudden changes in weather conditions are examples of unforeseen events that could lead to severe consequences without immediate mitigating actions. It is therefore particularly important that the bridge team be cognizant of potential threats and disturbances likely to act on the system and have an idea of how to act if the worst-case scenarios should materialize. In a DSA perspective, it is emphasized that each agent's SA should be compatible in a manner that binds collaborative systems together (Stanton *et al.*, 2010). Although the officer in command is responsible for the safe approach and positioning of the vessel, the co-pilot should be able to provide support whenever needed. Contingency planning as a team activity prior to the operation may therefore facilitate a shared understanding of potential threats and disturbances. We acknowledge, however, that shared SA is problematic because personal differences in schemata, skills, and training influence how information is processed. Nonetheless, there remains a need for shared information when the bridge team members have overlapping responsibilities. A high degree of shared knowledge about potential threats and disturbances may facilitate and promote coordinated actions in stressful situations, when decisions must be made rapidly.

### **Communication practices**

Checklists are important tools in the planning stage prior to entering an offshore facility's safety zone. From a DSA perspective, checklists are an important tool for ensuring that SA-relevant information is transferred within the system. Although checklists do not contain SA-relevant information, they can be used to ensure that SA-relevant information is retrieved. The maritime industry often looks to the aviation industry for guidance regarding the use of checklists. In the aviation industry, checklists are used when configuring the plane. Two of the stated objectives that are generally highlighted are to 'allow mutual supervision (cross checking) among crew members' and to 'enhance a team (crew) concept (. . .) by keeping all crew members "in the loop"' (Degani & Wiener, 1993, p. 347). To meet these objectives, the manner in which the checklists are completed is relevant. Surprisingly, significant variation in the use of checklists on board the vessels was observed. Although practices on some of the vessels allowed for mutual supervision and/or keeping both bridge team members informed, other vessels did not seem to utilize this potential because the checklists were generally completed by a single officer or a

cadet. In addition, checklists were sometimes conducted by the bridge team that was going off shift rather than the bridge team that was responsible for safe navigation. In such cases, the checklists did not ensure information exchange between external agents (e.g., technical equipment and the offshore facility) and the officers that depended on the information to achieve SA for the task at hand. This practice may indicate a false sense of security in that completing checklists becomes a task rather than a safeguard.

Previous research lends support to the idea that higher-performing teams transfer information between team members to a greater extent than lower-performing teams (Westli, Johnsen, Eid, Rasten, & Brattebo, 2010). It follows from a DSA perspective that each team member's SA should be compatible for the system as a whole to function well (Stanton *et al.*, 2006). Considering that the situation on board a PSV is dynamic and involves extensive flow of information, accurate information exchange among bridge team members is especially important. In particular, information exchange must support each officer's SA needs regarding their function in the team. An example highlighted in this paper concerns observations that indicated that the co-officer acknowledged pre-warnings in the DP system without transferring the potentially essential information to the DP operator. In this case, the DP operator's SA could have been affected by shortcomings in information exchange.

Practices related to the transfer of command were also highlighted in our study, both during shift handover and during shifts. For the officer in command to acquire the information necessary for his/her SA, an exchange of information about the vessel's operational status must precede the transfer of command; however, our observations indicate that command was occasionally transferred during a shift without such an exchange. Although the information is available from tools at the bridge, such as monitors and control panels, verbal exchange is conducive to intuitive understanding. A practice that allows technology to dominate exchanges of information may therefore delay the duty officers' achievement of SA. It is a reasonable assumption that consistent transfer of operational information, both during and between shifts, will reduce the likelihood of misunderstandings.

According to Smith-Jentsch *et al.* (1998), there is a distinction between information exchange and communication: A critical dimension of communication is *how* information is exchanged. The use of standard communication phrases is one of the most important factors in communication in safety-critical organizations. This practice enables quick and effective communication while simultaneously reducing the likelihood of misunderstandings (International Air Transport Association, 2011). Standard Maritime Communication Phrases (International Maritime Organization, 2005) include, for instance, standard communication phrases for the transfer of command on the bridge; however, the use of standardized phrases to indicate the transfer of command, such as 'You are now in command' or 'I am now in command', was not observed. This finding was surprising because their use is proposed in the Standard Maritime Communication Phrases. The usefulness of such phrases is further emphasized by the fact that confusion about the transfer of command was a contributory factor in two cases of collisions between attendant vessels and offshore facilities on the Norwegian continental shelf in the last decade (Oltedal, 2012). Our observational findings suggest that the limited use of standard maritime communication phrases and closed-loop communication during transfer of command might increase the risk of misunderstandings regarding each team member's role and responsibilities.

### **Interrupting and distracting elements**

Interruptions and distractions pose a serious threat because of their impact on the distribution of the team members' attention. In previous studies in the maritime industry (Grech, Horberry, & Smith, 2002) and other industries (e.g., Jones & Endsley, 1996; Sneddon, Mearns & Flin, 2006), failure to monitor or observe was the most common cause of loss of SA. In other words, inadequate transfer of information between the operator and other agents in the system preceded loss of SA. Our observations and statements from the PSVs indicate that concurrent task management was frequent and that it occasionally shifted attention away from the bridge team's responsibilities to monitor other agents in the system (e.g., monitors and the surrounding environment). Concurrent non-essential tasks highlighted in this study include administrative tasks, use of electronic devices, and non-essential conversations. These tasks were conducted while the bridge team had important monitoring responsibilities related to both the technical equipment and the surrounding environment. Whereas some of the informants described conflicting requirements between administrative tasks and navigational responsibilities, we have no data that could explain why they chose to let other disturbing elements interfere with their navigational responsibilities. However, it is a reasonable assumption that if the DP operator turns his/her back on technology for long periods, trust in technology might be an influencing factor.

Regardless of whether disturbing/interrupting elements arise from the need to complete administrative tasks, the use of electronic devices, or non-essential conversations, they require attention and cognitive resources. Although the officers frequently directed attention towards their monitoring tasks, distractions might still have significant implications for the bridge teams' SA requirements. Even if attention is shifted in a timely manner, additional cognitive effort is required to update SA (Loukopoulos *et al.*, 2009). This problem is recognized in the aviation industry, in which the 'sterile cockpit' rule was implemented after a series of aviation accidents. The rule prohibits the crew from performing non-essential duties and conducting non-essential conversations in specific safety-critical situations (Sumwalt, 1993). The maritime industry has also acknowledged the risk associated with interruptions and distractions. For instance, the NWEA guidelines state that during the planning stages and approach to offshore facilities, all non-essential tasks should be stopped or delegated (The North West European Area Guidelines, 2009). From a DSA perspective, this practice makes sense because it is critical to eliminate factors that can hamper timely and adequate transfer of SA-relevant information in day-to-day operations.

### **Conclusions**

By consideration of the physical and social environment that surrounds the bridge team, DSA models acknowledge that SA-related information is held both by human and by non-human agents in the system, such as DP, Electronic Chart Display and Information Systems, wind riders, and documents. SA is thus considered to be a system property rather than an individual property. Because both human and non-human agents comprise a network, in which each agent holds SA-specific information, each agent's SA is constantly modified and updated through information exchange and interactions with other agents, including the technological environment. In this manner, a DSA approach better captures the dynamic characteristic of complex collaborative systems than individual approaches to SA. The bridge of a PSV represents a typical collaborative system in which bridge team members interact with each other and with external agents in a high-tech environment. To our knowledge, no previous studies have examined SA as a distributed phenomenon in

the maritime industry. Our study is particularly relevant because the paper provides a description of conditions that may influence the bridge teams' SA in day-to-day operations, and adds to our understanding of SA as a distributed phenomenon. By noting possible areas for improvements regarding planning activities, communication practices, and management of distracting/interrupting elements, the study provides an opportunity for the maritime industry to establish shipboard practices that meet the bridge team's information needs in a complex environment. The study might also provide a window into studying SA as a distributed phenomenon in other industrial settings; additionally, because planning, communication, and management of interrupting/distracting elements are essential tasks in many collaborative systems, our findings may have implications for other industrial settings as well.

Our findings may have practical implications for increasing DSA and reducing the risk of adverse outcomes during bridge operations. First, we argue that planning as a team activity may increase the likelihood that SA information will be shared and properly assessed, because team members may possess different information. Second, communication emerges as a key factor in connecting and maintaining the parts of a distributed system. It is therefore important that communication practices facilitate efficient and reliable transfers of information between agents through increased use of closed-loop and standardized communication. Finally, because achievement and maintenance of SA require focused attention, management of interrupting/distracting elements is important. Impaired attention may delay awareness of information provided by other agents, which may in turn affect the bridge team's SA needs.

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# Effects of leadership style and psychological job demands on situation awareness and the willingness to take a risk: A survey of selected offshore vessels



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## ABSTRACT

We examined how active and passive leadership styles (i.e., authentic leadership and laissez-faire leadership) and psychological job demands combine and influence safety related outcomes in terms of situation awareness and the willingness to take a risk in day-to-day operations. To this end, a conceptual model was developed, and by means of path-analysis with a maximum likelihood estimation the model was tested using survey data collected on board offshore vessels within a Norwegian controlled shipping company. The model was tested in both the deck department ( $n = 178$ ) and the machine department ( $n = 103$ ). The results indicated that relatively little variations in job demands could be explained by laissez-faire leadership (6.3% and 3.7% in the deck and machine department samples, respectively). With regards to situation awareness, on the other hand, 21.6% of the variations could be explained by the combined influence of authentic leadership, laissez-faire leadership and job demands in the deck department sample, whereas 27.5% of the variations in situation awareness could be explained by the two leadership styles alone in the machine department sample. In the deck department sample, job demands and situation awareness explained 18.9% of the variations in risk-taking, whereas these two variables explained 30.8% of the variations in the machine department sample. The differences between the deck department sample and the machine department sample are explained in the manuscript. The study expands our understanding of how active and passive leadership styles may combine with psychological job demands to influence situation awareness and safety in maritime operations.

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## 1. Introduction

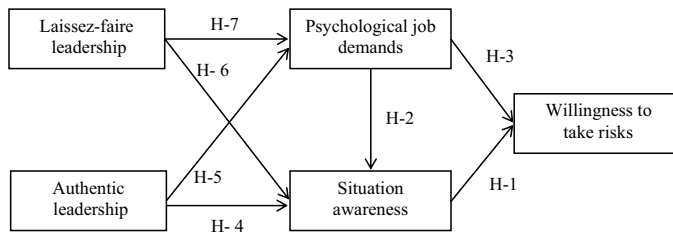
Accident analysis has increased our understanding of how major accidents may be attributed to unfavourable interactions at several levels in the organization (Reason, 1997). For instance, subsequent accident analysis from the capsizing of the passenger ferry Herald of Free Enterprise on March 27, 1987, found evidence of substandard leadership, production pressure, lack of risk factor awareness and violation of safety procedures. It concluded that 'from top to bottom the body corporate was infected with the disease of sloppiness' (Sheen, 1987, p. 14). In addition to extensive human and economic losses, the Herald of Free Enterprise capsizing had a significant impact on safety management within the maritime industry worldwide. In particular, the capsizing is considered to have initiated the International Safety Management

Code, which provides a minimum standard for the safe management and operation of ships worldwide. However, several decades after the Herald of Free Enterprise capsizing, substandard leadership has been identified as a significant contributing cause of 94 maritime navigational accidents in the UK (Batalden and Sydnese, 2013). A better understanding of how leadership personnel can reinforce safety behaviours and promote safety awareness in the maritime industry is therefore needed. In addition there is a need to improve our understanding of how managerial pressure towards increased productivity may constitute a threat to accident prevention. To this end, the overarching purpose of the present study is to simultaneously evaluate how active and passive leadership styles (i.e., authentic and laissez-faire leadership) and psychological job demands may combine to influence situation awareness (SA) and safety behaviour (i.e., willingness to take risks) during day-to-day operations.

A conceptual model (see Fig. 1) was developed and tested on board a selection of offshore vessels.

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**Fig. 1.** Theoretical model showing hypothesized relationships among the willingness to take risks, situation awareness, psychological job demands, authentic leadership and laissez-faire leadership.

To the best of our knowledge, this model expands our understanding of how active/passive leadership styles and psychological job demands combine to maintain SA and minimize unsafe behaviour. The theoretical basis for the model and suggested relationships in Fig. 1 are further outlined in the following sections.

### 1.1. Theory and hypothesis

#### 1.1.1. Willingness to take risks

Risk taking behaviour typically refers to ignorance of safety procedures, carrying out forbidden activities and incorrect task performance, and similar form of non-compliance (Rundmo and Hale, 2003), and has proved to be strongly associated with accidents and incidents (Mearns et al., 2001). In the literature, risk-taking behaviour is recognized as a consequence of latent conditions in the organization – such as substandard leadership and other unfavourable workplace factors (Reason, 1997). For instance, Rundmo (1996) found that management prioritization of production goals at the cost of safety goals was the strongest predictor for workers' acceptance of procedure violations. Several other studies have also proved that there is a link between the management's commitment to safety and the employees' risk taking behaviour (e.g., Bosak et al., 2013; Yule and Flin, 2007). In a study from the maritime industry, Olteidal (2011) found that shipping companies' commitment to safety combined with on board leadership influence risk perception and safety oriented behaviour. The results of several studies suggest that a rather large proportion of accidents and incidents in the maritime industry are, at least in part, caused by some sort of human error (Hetherington et al., 2006; Sandhåland et al., 2015b, 2015a; Wagenaar and Groeneweg, 1987). Further research is therefore needed to investigate factors that may contribute to human errors. For this reason, willingness to take risks is used as the outcome variable in our conceptual model.

#### 1.1.2. Situation awareness

Loss of situation awareness (SA) has proved to be a significant antecedent of human error in the maritime industry according to previous studies (Grech et al., 2002; Sandhåland et al., 2015a, 2015b). SA is then understood as 'being aware of what is happening around you and understanding what that information means to you now and in the future' (Endsley, 2012, p.13). That is, the seafarers have to accurately identify key aspects of the environment (SA level 1), understand the meaning of what they sense (SA level 2) and have a good idea of what might occur (SA level 3). The concept of SA is closely linked to decision-making and is generally seen as a prerequisite to making good decisions (Endsley, 1995). When considering decision making in the context of unsafe behaviour, it is useful to differentiate between *taking a risk* and *running a risk*. While the former refers to deliberate risk taking, the latter refers to situations where seafarers do not recognize their behaviour as

problematic (Rosness et al., 2004). This might be caused by missing information or insufficient knowledge and thus result in impaired assumptions, which in turn influence the ability to make good decisions. However, even though *taking a risk* (e.g., procedure violation) is deliberate, the potential bad outcome typically is not (Reason, 2008). Either way, it could be argued that inadequate SA will likely precede risky behaviour. While a person *taking a risk* is likely to have misjudged the consequences of his/her behaviour (SA level 3), a person *running a risk* is likely to have missed critical information or have failed to comprehend the information properly (SA level 1 and SA level 2). It is therefore assumed that loss of SA at all levels may affect risk-taking behaviour. We therefore propose the following research hypothesis:

**H-1.** SA is negatively related to the willingness to take risks.

#### 1.1.3. Psychological job demands

Overload in psychological job demands occurs when the demands exceed the individual's resources (Karasek, 1979). The construct may be defined as 'the extent to which the work pace is high and the availability of sufficient time to execute the required work' (Demerouti et al., 2001, p. 281). In other words, overload in psychological job demands refer to situations where the worker has too much to do, has irregular workload so that work piles up, has to work at a rapid pace or has to work overtime to get the job done. In previous studies overload in psychological job demands has been linked to negative outcomes. For instance, in a study performed by Li and colleagues (Li et al., 2013) they found that among crude oil production workers the level of psychological job demands was related to emotional exhaustion which in turn was related to safety outcomes (i.e. near-misses and injuries). This is in line with a study performed by Lourel et al. (2008), who found that psychological job demands predicted emotional exhaustion among fire-fighters. In addition, previous studies have found an association between psychological job demands and physical health issues such as the common cold (Mohren et al., 2001) and heart disease (Netterstrom et al., 2006).

Because the maritime industry to a large extent necessitate continuous work operations, safe working conditions depend on vigilant workers who are able to continuously achieve and maintain SA. However, overload in job demands is a frequently cited factor that may increase the level of stress and fatigue (MacDonald, 2003), which in turn is associated with the risk of deteriorated SA (Sneddon et al., 2013). We therefore assume that overload in psychological job demands has a negative effect on seafarers' ability to achieve and maintain SA. We further assume that overload in psychological job demands has a direct effect on risk prone behaviour. In line with these propositions, the following research hypotheses are proposed:

**H-2.** Psychological job demands are negatively related to SA.

**H-3.** Psychological job demands are positively related to the willingness to take risks.

#### 1.1.4. Leadership

According to Ford and Harding (2011) Bernard M. Bass was the first to introduce the term 'authentic leadership' in his theory of 'transformational leadership'. He included the concept of 'authentic leadership' as an answer to critics who pointed out the possibility for 'narcissistic and authoritarian managers to masquerade as transformational leaders' (Ford and Harding, 2011, p. 464). Bass argues that 'authentic transformational leadership must rest on a moral foundation of legitimate values' (Bass and Steidlmeier, 1999, p. 184). Following Bass's introduction of 'authentic leadership' several authors have further developed the concept. In this paper we rely on Avolio and Gardner's (2005) theory on authentic leadership that suggest that authentic leadership is composed of the following four components: Self-awareness, relational transparency, balanced processing and internalized moral perspective. *Self-awareness* refers to an awareness of how the leader makes meaning of the world and how that meaning influences the way the leader views him/herself. *Relational transparency* is related to how the individual presents his/herself to others, such as openly sharing information and honestly expressing one's thoughts and feelings, thus presenting a true self. *Balanced processing* refers to leaders who objectively consider all relevant data before they reach a decision. Authentic leaders also encourage workers to express viewpoints that challenge the leader's own position. Finally, *internalized moral perspective* refers to the fact that authentic leaders are guided by their own moral standards in their decision-making and behaviour. Instead of complying with the expectations of others, authentic leaders hold their own positions (Shamir and Eilam, 2005). Authentic leaders are aware that their behaviour and decisions will send important signals to others and thus influence worker behaviour. In this way, authentic leaders serve as positive behavioural models (Avolio et al., 2004; Ilies et al., 2005). In a study from the maritime industry, Borgersen et al. (2013) found that authentic leadership by masters was positively related to crew perceptions of safety. This is in accordance with a study performed by Nielsen et al. (2013b) in which a positive relationship was demonstrated between authentic leadership and safety climate in the oil and gas industry. These authors also found that authentic leadership was negatively related to workers' risk perception. Overall, the accumulated data suggest that authentic leadership has a positive effect on safety-related outcomes. The importance of a safety-oriented shipboard management is also highlighted in other studies (e.g., Håvold, 2010; Hetherington et al., 2006; Oltedal and Wadsworth, 2010; Oltedal and Engen, 2009). Thus, it would be expected that safety is a prioritized goal among authentic leaders, and that this is reflected in the leaders' behaviour and statements (Hystad et al., 2014). Assuming that safety and the well-being of workers are prioritized goals, authentic leaders will go to great lengths to ensure that job demands do not exceed the workers' abilities and resources. Authentic leadership role modelling encourages workers to prioritize safety. It is further assumed that workers who prioritize safety goals will have a greater awareness of safety information and establish greater SA during daily operations. This leads to the following research hypotheses:

**H-4.** Authentic leadership is positively related to SA.

**H-5.** Authentic leadership is negatively related to psychological job demands.

Theories on authentic leadership have not been without controversy, however. For instance, Wetzel (2015) argues that the idea of a 'stable core self' in the sense that it can be recognized and explained both to our self and others is a myth (p. 41). A leader will thus always fail in his/her search for authenticity or his/her true self. Ford and Harding (2011) likewise discuss the notion of a 'true self' and argues that the theory of authentic leadership 'refuse to acknowledge the rounded subject as someone full of contradictions' (p. 476). Wetzel (2015) also argues that leaders do not hold unambiguous roles in organizations. Rather, leaders face contradictions in expectations and demands that influence their behaviours. In other words, both leaders and organization lack a stable core – whereupon authenticity will be impossible. This argument is supported by a study conducted by Nyberg and Sveningsson (2014) who reported that leaders experience a tension between their authenticity and the expectations of other members in the organization. Consequently these leaders reported that they had, at times, restrained their authenticity in order to be perceived as good leaders. According to the authors, it is thus misleading to examine leadership disconnected from the context in which it takes place. We acknowledge the critique that has been raised towards the concept of authentic leadership – in particular, how expectations of others may challenge the authenticity in the masters' leadership. That being said, when it comes to the effect of authentic leadership on followers' behaviour it might be argued that it is whether or not the masters leadership is *perceived* as authentic that is important rather than whether or not he/she demonstrates "true" authenticity in his/her leadership. In other words, we maintain that it is reasonable to assume that if the crew perceives the master's leadership as authentic that will have a positive effect on the crew's safety related behaviour.

In contrast to constructive forms of leadership, *laissez-faire* leadership represents little to no exchange between the leader and workers and has shown to be negatively associated with worker job satisfaction (Judge and Piccolo, 2004). According to Bass (1997), *laissez-faire* leaders 'avoid accepting their responsibilities, are absent when needed, fail to follow up requests for assistance, and resist expressing their views on important issues' (p. 134). Surprisingly few studies have examined the effect of *laissez-faire* leadership on safety related outcomes as opposed to studies concerning more active leadership. However, Kelloway et al. (2006) found support for passive and active leadership as empirically distinct constructs in a sample of part-time workers. These authors argue that active and passive leadership should not be treated as opposite ends of the same continuum, but rather should be considered as distinct constructs. They also found that passive leadership explained unique variance in safety-related outcomes over and above what was explained by active leadership (i.e., transformational leadership). Another study that examined the effects of *laissez-faire* leadership on safety-related outcomes was conducted by Zohar (2002) who, not surprisingly, found that *laissez-faire* leadership was negatively related to the group-level safety climate (i.e., preventive actions considered, or taken, by the superior). Compared with active leadership (i.e., authentic leadership as described above), it is expected that *laissez-faire* leadership will have the opposite effect on SA and psychological job demands. We therefore propose the following research hypotheses:

**H-6.** *Laissez-faire* leadership is negatively related to SA.

**H-7.** *Laissez-faire* leadership is positively related to psychological job demands.

## 2. Methods

### 2.1. Participants and procedures

The present study was conducted in a Norwegian controlled shipping company that owns and operates a large fleet of purpose-built offshore vessels. Questionnaires were sent out via the shipping company's onshore shipping and forwarding agent to 926 crew members on board 22 vessels. In total, 402 questionnaires were returned, yielding a response rate of 43.4%. We were interested in participants working in either the deck or engine departments. Therefore, questionnaires from respondents working in the galley department were excluded, leaving an eligible research sample of  $N = 281$  ( $n = 178$  in the deck department and  $n = 103$  in the engine department).

Ten different nationalities were represented in the deck sub-sample. Norwegians constituted the largest group (50.6%), followed by Filipinos (29.2%). Overall, 65.2% were permanent employees, 29.2% were on temporary contracts and 3.4% were apprentices (2.2% missing responses). The mean length of the respondents' seafaring career was 14.6 years, and the mean length of employment with the shipping company was 3.8 years.

Ten different nationalities were also represented in the engine sub-sample. Norwegians constituted the largest group (31.1%), followed by Filipinos (30.1%) and Polish employees (25.2%). Permanent employees accounted for 52.4% of the sample, whereas 36.9% were on temporary contracts and 9.7% were apprentices (1% missing responses). The mean length of the seafarer career was 14.3 years, and the mean length of employment with the shipping company was 3.3 years. Thus, there were minor differences in demographic variables between the two samples.

This research was reviewed and approved by the Norwegian Social Science Data Service, the institution that serves as the University of Bergen's Privacy Ombudsman for Research. Participation was voluntary, and all participants gave their informed consent and were informed that they could withdraw from the study at any time.

### 2.2. Measures

#### 2.2.1. Authentic leadership

Authentic leadership was measured by the Authentic Leadership Questionnaire (Gardner et al., 2011). The respondents were asked to rate the behaviour of the master on 16 items using five response categories (1 = *not at all*; 5 = *often, nearly always*). The questionnaire measures the four components of authentic leadership: Self-Awareness (e.g., "Seeks feedback to improve interactions with others"), Relational Transparency (e.g., "Is willing to admit mistakes when they are made"), Balanced Processing (e.g., "Solicits views that challenge his or her deeply held positions") and Internalized Moral Perspective (e.g., "Demonstrates beliefs that are consistent with actions"). Only a total mean authentic leadership score was computed for the present study (Cronbach's  $\alpha = 0.94$ ).

#### 2.2.2. Laissez-faire leadership

Laissez-faire leadership was measured by the Multifactor Leadership Questionnaire (Avolio and Bass, 2004). The respondents were asked to rate the behaviour of the master on five items with response categories ranging from 1 (*not at all*) to 5 (*very often or always*). Examples of items included: "has avoided telling me how to perform my job" and "has steered away from showing concern about results". Three items that are negatively scored were reversed before creating a total mean laissez-faire leadership score. Cronbach's  $\alpha$  in the present study was 0.71.

#### 2.2.3. Psychological job demands

Psychological job demands were measured by four items drawn from the General Nordic Questionnaire for psychological and social factors at work (QPS<sub>nordic</sub>) (Dallner et al., 2000). The QPS<sub>nordic</sub> is a comprehensive questionnaire designed to measure a wide variety of psychological and social factors at work. It contains 80 items that are used to form 26 different scales. In the current study we chose the four items constituting the *quantitative demands* scale, as this was deemed most relevant for our purpose (as opposed to decision- and learning demands). This scale measures the degree to which the work environment places demands on the individual in terms of time pressure ("Is it necessary to work at a rapid pace?") and work load ("is your work load irregular so that work piles up?", "Do you have to work overtime?" and "do you have too much to do?"). The quantitative demands scale has previously demonstrated good internal- and concurrent validity (Wännström et al., 2009). All items were rated on a five-point scale ranging from 1 (*seldom or never*) to 5 (*very often or always*). Cronbach's  $\alpha$  in the present study was 0.71.

#### 2.2.4. Situation awareness

To measure the seafarers' SA, respondents were asked to rate themselves on a context-general situation awareness scale (Sætrevik, 2013). The questionnaire consists of 13 items that are scored on a five-point scale ranging from 1 (*completely disagree*) to 5 (*completely agree*). This instrument measures SA according to the three levels from Endsley's (1995) theoretical model. Four of the items reflect Level 1 (e.g., "I sometimes lose track of safety due to receiving too much information at the same time"), five of the items reflect Level 2 (e.g., "I know which situations in my work involve higher risk than others"), and finally, four items reflect Level 3 (e.g., "I plan ahead in order to handle various adverse incidents that may arise"). The questions in the scale use words that are relevant across different work settings and may therefore be characterized as context general. The advantage of using a context general measure is that results can be easily compared among different work settings on board a vessel (i.e., the engine and deck departments). The results can also be generalized to other industries (Sætrevik, 2013).

Five items that were negatively scored were reversed before creating a total mean SA score. Cronbach's  $\alpha$  in the present study was 0.78.

#### 2.2.5. Willingness to take risks

Willingness to take risks was measured by seven items that were adapted from a review of the relevant literature (e.g., Nielsen et al., 2013a, 2013b). The participants were required to respond to items such as "I have been in situations where I exposed myself to danger to get the work done" and "To get the job done, I sometimes 'cut corners' with regards to safety" on a five-point response scale ranging from 1 (*very seldom, or never*) to 5 (*very often, or always*). Cronbach's  $\alpha$  in the present study was 0.73.

### 2.3. Statistical analyses

To test Hypotheses 1–7, we performed path-analyses with a maximum likelihood estimation using Stata version 13.1. All analyses were conducted separately for the deck and machine sub-samples. In addition, we used a generalization of the Huber/White/sandwich estimator (Rogers, 1994; Williams, 2000) that relaxes the assumptions of normality in the errors and is also robust to heteroskedasticity. This estimator also relaxes the usual requirement that the observations be independent (i.e., independence of errors) and replaces it with the assumption of independence between clusters. In other words, the observations are

assumed to be independent across the 22 ships included in our study, but not necessarily within ships.

Model fit was judged by examining the magnitude and statistical significance of path loadings, the variance explained and the standardized root mean squared residual (SRMR). The coefficient of determination (CD) and the SRMR are the only goodness-of-fit statistics that Stata provides when the Huber/White/sandwich estimator is used.

### 3. Results

Means, standard deviations and intercorrelations between the study variables are presented in Table 1.

In the following sections, the combined results for both the deck and the machine departments are presented. In both samples, situation awareness was negatively related to the willingness to take risks,  $\beta = -0.20$ ,  $p = 0.003$  and  $\beta = -0.35$ ,  $p < 0.001$  for the deck and machine departments, respectively, thereby confirming Hypothesis 1.

Both Hypotheses 2 and 3 were confirmed in the deck department sample, as job demands were negatively related to SA ( $\beta = -0.15$ ,  $p = 0.02$ ) and positively related to the willingness to take risks ( $\beta = 0.34$ ,  $p < 0.001$ ). In the machine department sample, however, job demands predicted willingness to take risks ( $\beta = 0.41$ ,  $p < 0.001$ ), but SA did not ( $\beta = -0.09$ ,  $p = 0.33$ ).

Authentic leadership and laissez-faire leadership were significantly associated with SA in both the deck ( $\beta = 0.26$ ,  $p = 0.002$  and  $\beta = -0.29$ ,  $p < 0.001$ , respectively) and machine department samples ( $\beta = 0.47$ ,  $p < 0.001$  and  $\beta = -0.21$ ,  $p = 0.02$ , respectively), confirming Hypotheses 4 and 6.

Addressing Hypotheses 5 and 7, authentic leadership did not significantly predict job demands in either the deck or machine department samples, whereas laissez-faire leadership was significantly associated with job demands in the deck department sample ( $\beta = 0.25$  and  $p = 0.02$ ) and “marginally” significantly associated with job demands in the machine department sample ( $\beta = 0.19$  and  $p = 0.051$ ). Hypothesis 5 was thus not supported, whereas Hypothesis 7 was partially supported.

Based on the results from the initial path-analyses, we re-specified the hypothesized models taking into account the non-significant relationships. In the re-specified model, the association between laissez-faire leadership and job demands was also statistically significant in the machine department ( $\beta = 0.19$  and  $p = 0.048$ ). The re-specified models are shown in Figs. 2 and 3.

As shown in Figs. 2 and 3, relatively little of the variations in job demands could be explained by laissez-faire leadership (6.3% and 3.7% in the deck and machine department samples, respectively). With regards to SA, on the other hand, 21.6% of the variations could be explained by the combined influence of authentic leadership, laissez-faire leadership and job demands in the deck department sample, whereas 27.5% of the variations in SA could be explained

by the two leadership styles alone in the machine department sample. In the deck department sample, job demands and SA explained 18.9% of the variations in the willingness to take risks, whereas these two variables explained 30.8% of the variations in the machine department sample. In terms of model fit, the SRMR for both models indicated a well-fit model (SRMR for deck department = 0.042; SRMR for machine department sample = 0.051) based on the usual recommendations (Hu and Bentler, 1998; McDonald and Ho, 2002).

### 4. Discussion

Our point of departure was a conceptual model examining how active and passive leadership styles (i.e., authentic and laissez-faire leadership) and psychological job demands influence SA and the willingness to take risks during day-to-day operations. With a few notable exceptions, the results support our hypothesized model in both the deck and the machine department samples. In sum, the current study highlights leadership style, psychological job demands and SA as antecedents to risk taking behaviour. However, some differences between the samples are worth noting. While the effect of job demands on SA proved to be significant in the deck department, it proved to be non-significant in the machine department. Additionally, the effect of authentic leadership on SA appeared to be noticeably stronger in the machine department ( $\beta = 0.47$ ) than in the deck department ( $\beta = 0.26$ ). These findings may at first seem surprising because personnel in the machine department relate to and interact with the chief engineer to a greater extent than the master in day-to-day operations. Thus, from a perspective of interaction alone, one would have expected a reduced effect of the masters' leadership style (i.e., authentic leadership) in the machine sample compared with the deck sample. However, even though the master is not involved in the day-to-day operations in the machine department, he is still the superior officer for the technical branch and may hold an important role in influencing the unique working environment of the vessel and the organizational culture and safety climate on board. That being said, personnel in the deck department will, to some degree, relate to the chief officer and the bosun as their immediate superiors (e.g., during loading/offloading operations) and in this way interact with leaders other than the master. However, personnel in the deck department may interact with the master to a greater extent than personnel in the machine department in day-to-day operations. From a review of authentic leadership literature, Yammarino et al. (2008) have called for a multilevel perspective of leadership research, and our findings may indicate that authentic leadership behaviour could have a strong and lasting influence on organizational culture above the immediate leader-follower relationship. The most notable difference beyond this was that in the machine department sample, the combination of job demands and SA explained 30.8% of the variations in the

**Table 1**

Means, standard deviations and intercorrelations for all of the included variables presented separately for the deck and machine departments.

Variables	1	2	3	4	5	M	SD
1. Authentic leadership	–	–0.04	–0.09	0.48***	–0.23*	3.85	0.66
2. Laissez-faire leadership	–0.11	–	0.32*	–0.26**	0.30**	2.55	0.98
3. Psychological demands	–0.16*	0.28***	–	–0.19*	0.47***	2.48	0.57
4. Situation awareness	0.30***	–0.35***	–0.26***	–	–0.41***	3.90	0.47
5. Risk taking	–0.11	0.37***	0.36***	–0.30	–	1.86	0.67
M	3.93	2.36	2.32	3.90	1.77	–	–
SD	0.73	0.87	0.71	0.43	0.69	–	–

Note: Statistics for the deck department are shown below the diagonal and statistics for the machine department are shown above the diagonal.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < 0.001$ .

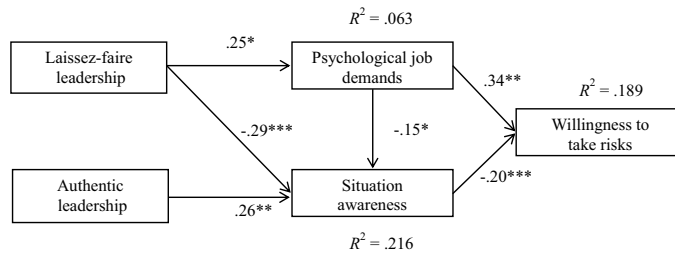


Fig. 2. Final model for the deck department sub-sample. Standardized coefficients are shown. SRMR = 0.042; CD = 0.225. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

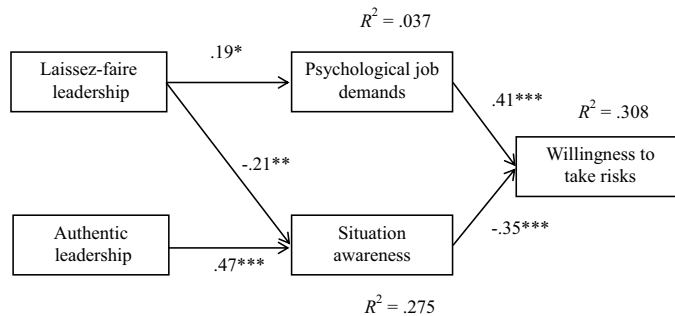


Fig. 3. Final model for the machine department sub-sample. Standardized coefficients are shown. SRMR = 0.051; CD = 0.301. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

willingness to take risks compared to 18.9% in the deck department sample. A potential explanation for these findings could be that two navigators man the bridge, whereas the machine department is typically manned by one engineer. For instance, during particularly demanding phases of the voyage, such as cargo operations inside the offshore facility safety zones, the bridge is manned by two navigators, while machinery functions are monitored and taken care of by one watch-keeping engineer (Guidelines for offshore marine operations, 2013). Therefore, some sort of social control between the navigators may prevent procedure violations and other risk prone behaviour despite the psychological job demands.

In the following sections, we discuss each variable in our conceptual model with regard to implications for practice and previous research.

#### 4.1. Leadership

Our findings have implications both for practice and leadership research and its effect on safety-related outcomes. First, this study supports Skogstad et al. (2007) argument that laissez-faire leadership should be seen as a distinct form of destructive leadership as opposed to a type of zero-leadership. Although the current study has demonstrated the undesirable effects of laissez-faire leadership on both psychological job demands and SA, further research is needed from other private or public sector organizations to examine the effect of laissez-faire leadership on other safety related variables. It is notable that laissez-faire leadership was a stronger predictor of psychological job demands than authentic leadership in both samples. This should prompt researchers to consider negative forms of leadership because previous research on the effect of leadership styles on safety outcomes has mainly examined active forms of leadership, such as transformational

(Zohar, 2002) and authentic leadership (Hystad et al. 2014). Our findings lend support to Kelloway et al. (2006) argument that active and passive leadership styles should be seen as distinct constructs and that future research on the subject should include both active and passive leadership styles. Second, our findings on the effect of authentic leadership support previous research in that authentic leadership has a positive effect on safety-related outcomes within the maritime industry (e.g., Nielsen et al., 2013b). Furthermore, our results indicate that authentic leadership improves SA. The aforementioned ability of authentic leaders to engage in balanced processing and awareness of worker needs (Avolio et al., 2004) may explain these positive outcomes related to authentic leadership. This in turn may have practical implications for the shipping companies relative to recruitment processes and leadership development. The shipping industry differs from many other industries in that the internal recruitment of unit leaders (i.e., masters, chief officers and chief engineers) is based on assessments of their performances in positions of lower rank. We acknowledge that some shipping companies offer formal leadership training for unit leaders. However, our findings indicate that shipping companies should consider placing greater emphasis on formal leadership training to avoid the negative consequences of laissez-faire leadership and promote the beneficial aspects of positive leadership behaviour.

#### 4.2. Psychological job demands

Not surprisingly, our study showed that psychological job demands have a strong effect on risk taking behaviour in both samples. That is, factors such as job demand overload, rapid pace of work or work that piles up due to irregular workload increase the willingness to take risks. A recurring theme in previous research is that risk-taking behaviour, such as a procedure viola-



tion, is an important antecedent to accidents and incidents (Batalden and Sydnes, 2013; Dekker, 2005; Mearns et al., 2001). Our findings therefore further our understanding of the mechanisms underlying accidents and incidents in the maritime industry. It is interesting to note that psychological job demands had a strong effect on risk-taking behaviour in the context of goal conflicts. No organization exists solely for the purpose of being safe, and production of goods or services are vital to the existence of any organization. A proper balance between safety concerns and production goals is therefore a key issue to operate both safe and financially viable organizations (Reason, 1997). In day-to-day operations, conflicts between safety goals and production goals may, however, arise in safety critical organizations, such as those in the maritime industry. To describe how people relate to such situations, Hollnagel (2004) introduced the ETO principle (Efficiency-Thoroughness-Trade-Off), which is a way of noting the fact that trade-offs between efficiency and thoroughness is a common feature in human performance. In the context of safety, if job demands in terms of production pressure are very high, people are more willing to lower their demands for thoroughness, i.e., they are willing to take a greater risk to get the job done. The opposite might also be the case, but according to Rasmussen (1997), production goals in many organizations take priority over safety goals. In the present study, our data has not provided a clear picture of what work aspects affect the crews' psychological job demands and whether these are related to cognitive demands, physical demands or both. From a previous study of platform supply vessels in the North Sea, observational data indicate that compliance with demands for completing paperwork, documentation and work reports from time to time are in conflict with safe navigation procedures (Sandhåland et al., 2015a). This could indicate that cognitive demands may be of greater importance than physical demands in modern maritime operations. The exact nature and form of job demands in the maritime industry may be an area for further research. Our findings revealed, however, that psychological job demands have a minor effect on SA. This finding was surprising considering that factors associated with psychological job demands, such as stress and fatigue, had a negative effect on SA in previous studies (Sneddon et al., 2013). We therefore expected a stronger relationship between these variables. A potential explanation for these findings could be that employee training and professionalism contributed to a satisfactory SA, despite being exposed to high job demands.

#### 4.3. Situation awareness

From our previous discussion, it is interesting to note that authentic leadership had a positive and laissez-faire leadership had a negative relationship to SA. In the literature on SA, the cognitive perspective has been emphasized by Endsleys' (1995) three-level model of the operator's ability to (a) perceive, (b) comprehend, and (c) estimate possible future outcomes of an operational situation, such as maritime cargo operations. From this perspective, expert judgments and the behaviours of the individual operators are quite independent of other external subject matter. In other words, SA may be understood to be cognitive processes in the minds of individuals within a system. On the other hand, a system ergonomics perspective would emphasize the interaction between the operator and his/her immediate supervisor. From this perspective, SA may be seen as a process that occurs through interactions among operators, their supervisors, and decision support systems, such as satellite navigation systems or engine room control stations (Stanton et al., 2010). The results from both samples in the present study may indicate that a system ergonomic perspective may be useful in maritime operations.

Our study also reveals that SA is negatively related to the willingness to take risks. These findings are not surprising because a well-developed SA is normally seen as a prerequisite to good decision-making and safety-related behaviour (Endsley, 1995). From a system ergonomic perspective, it is important that both technological aids at the bridge and shipboard practices facilitate transaction of SA related information to the person who needs it in an accurate and timely manner (Stanton et al., 2010). Shipping companies should therefore prioritize measures that facilitate SA-related information transactions. First, the research literature on SA includes technological design principles that are believed to support the operator's abilities to manage information provided by the technology (Endsley, 2012). Shipping companies should therefore strive for SA-driven design processes that allow the technological environment to support the operators' SA needs. Second, shipping companies should establish shipboard practices that support transactions of SA-related information among team members. In this respect, effective routines for communication, planning and management of disturbing elements are important factors (Sandhåland et al., 2015a, 2015b). Finally, seafarers have to do more than simply perceive SA relevant information in the environment. In order to achieve SA for the task they must understand the integrated meaning of what they have perceived, in light of their goals (Endsley, 2012). Practical training and basic knowledge about the functionality of key components in the system are thus important factors in this context.

#### 4.4. The willingness to take risks

In both samples, reduced SA and increased psychological job demands were related to an increased tendency to engage in risk-taking behaviour. The combined effect of reduced SA and increased psychological job demands may limit an employee's ability to perceive, assess and consider future consequences of current actions. In other words, the cognitive appraisal of the situation will be reduced in favour of a more immediate and emotional assessment of the unfolding events. Thus, reduced SA and increased job demands may lead to more risk prone behaviour, which may be explained by the workers turning to a more emotionally driven decision making process, as Loewenstein et al. (2001) argued in their risk-as-feelings hypothesis where people, in response to critical incidents, have a tendency to rely on feelings when judging risk. According to Loewenstein et al. (2001), people's 'responses to risky situations (including decision making) result in part from direct (i.e., not cortically mediated) emotional influences, including feelings such as worry, fear, dread, or anxiety' (p. 270). Thus, the tendency to engage in more risk-oriented behaviour may be a consequence of a more emotionally driven decision process.

### 5. Limitations and conclusions

Self-reporting can in itself be problematic, but especially so in regard to the reporting of deviant work behaviours and treatment by leaders. It is easy to imagine that many employees might have been reluctant to provide truthful responses to questions about following prescribed safety procedures or taking risks that could compromise safety on board the vessels. Instead, crew-members might under-report such behaviours in fear of reprisals from their employer or job loss. That being said, we could also argue that self-reporting is the most practical measure of deviant behaviour. After all, the crew-member is the only one that is fully aware of the behaviours that he or she actually performs. Further, the response rate from the survey should ideally have been higher than what was actually achieved in this study. However, a response rate of

43.4% is acceptable compared with the response rate that normally is achieved in organizational research (Baruch and Holtom, 2008).

Apart from authentic leadership, the Cronbach's alphas in this study were all in the lower region of what is generally considered "acceptable" (i.e., 0.70). Although Cronbach alpha is the most widely known and reported indicator of a test's reliability, it is also considered a lower bound to reliability and known to give severe underestimates in many cases (Sijtsma, 2009). Cronbach's alpha should therefore be regarded as a conservative estimate of reliability. Moreover, Cronbach alpha also depends on the number of items in a test (Nunnally, 1978), with more items generally equaling higher alpha estimates. With the exception of situation awareness, the scales with relatively low alphas in this study all contain few items (between 4 and 7 items). Finally, the alphas obtained in this study are comparable with alphas reported in the existing literature (e.g., Sætrevik (2013) for situation awareness; Wännström et al. (2009) for job demands; Nielsen (2013) for laissez-faire).

This study provides support to our conceptual model suggesting that active and passive leadership styles (i.e., authentic and laissez-faire leadership) combine with psychological job demands and SA in ways that influence safety related outcomes (i.e., willingness to take risks). Specifically, the study points to the fact that laissez-faire leadership was a stronger predictor of psychological job demands than authentic leadership in both samples. However, both authentic leadership and laissez-faire leadership proved to be associated with SA. Thus, shipping companies should take notice of this when they recruit new leaders and evaluate or develop their leadership training programs. Not surprisingly, a high level of psychological job demands proved to be associated with the willingness to take risks. Therefore, leaders should strive for reasonable distribution of tasks among crew-members and provide a reasonable scheduling of tasks during the watch. Finally, SA also proved to be associated with the willingness to take a risk. Thus, shipping companies should therefore pay attention to factors that are believed to affect SA during day-to-day operations. For instance, establish good and sound procedures relative to communication, planning and management of distractions (Sandhåland et al., 2015a, 2015b).

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**Doctoral Theses at The Faculty of Psychology,**  
**University of Bergen**

<b>1980</b>	Allen, H.M., Dr. philos.	Parent-offspring interactions in willow grouse ( <i>Lagopus L. Lagopus</i> ).
<b>1981</b>	Myhrer, T., Dr. philos.	Behavioral Studies after selective disruption of hippocampal inputs in albino rats.
<b>1982</b>	Svebak, S., Dr. philos.	The significance of motivation for task-induced tonic physiological changes.
<b>1983</b>	Myhre, G., Dr. philos.	The Biopsychology of behavior in captive Willow ptarmigan.
	Eide, R., Dr. philos.	PSYCHOSOCIAL FACTORS AND INDICES OF HEALTH RISKS. The relationship of psychosocial conditions to subjective complaints, arterial blood pressure, serum cholesterol, serum triglycerides and urinary catecholamines in middle aged populations in Western Norway.
	Værnes, R.J., Dr. philos.	Neuropsychological effects of diving.
<b>1984</b>	Kolstad, A., Dr. philos.	Til diskusjonen om sammenhengen mellom sosiale forhold og psykiske strukturer. En epidemiologisk undersøkelse blant barn og unge.
	Løberg, T., Dr. philos.	Neuropsychological assessment in alcohol dependence.
<b>1985</b>	Hellesnes, T., Dr. philos.	Læring og problemløsning. En studie av den perseptuelle analysens betydning for verbal læring.
	Håland, W., Dr. philos.	Psykoterapi: relasjon, utviklingsprosess og effekt.
<b>1986</b>	Hagtvet, K.A., Dr. philos.	The construct of test anxiety: Conceptual and methodological issues.
	Jellestad, F.K., Dr. philos.	Effects of neuron specific amygdala lesions on fear-motivated behavior in rats.
<b>1987</b>	Aarø, L.E., Dr. philos.	Health behaviour and socioeconomic Status. A survey among the adult population in Norway.
	Underlid, K., Dr. philos.	Arbeidsløse i psykososialt perspektiv.
	Laberg, J.C., Dr. philos.	Expectancy and classical conditioning in alcoholics' craving.
	Vollmer, F.C., Dr. philos.	Essays on explanation in psychology.
	Ellertsen, B., Dr. philos.	Migraine and tension headache: Psychophysiology, personality and therapy.
<b>1988</b>	Kaufmann, A., Dr. philos.	Antisocial atferd hos ungdom. En studie av psykologiske determinanter.

	Mykletun, R.J., Dr. philos.	Teacher stress: personality, work-load and health.
	Havik, O.E., Dr. philos.	After the myocardial infarction: A medical and psychological study with special emphasis on perceived illness.
<b>1989</b>	Bråten, S., Dr. philos.	Menneskedyaden. En teoretisk tese om sinnets dialogiske natur med informasjons- og utviklingspsykologiske implikasjoner sammenholdt med utvalgte spedbarnsstudier.
	Wold, B., Dr. psychol.	Lifestyles and physical activity. A theoretical and empirical analysis of socialization among children and adolescents.
<b>1990</b>	Flaten, M.A., Dr. psychol.	The role of habituation and learning in reflex modification.
<b>1991</b>	Alsaker, F.D., Dr. philos.	Global negative self-evaluations in early adolescence.
	Kraft, P., Dr. philos.	AIDS prevention in Norway. Empirical studies on diffusion of knowledge, public opinion, and sexual behaviour.
	Endresen, I.M., Dr. philos.	Psychoimmunological stress markers in working life.
	Faleide, A.O., Dr. philos.	Asthma and allergy in childhood. Psychosocial and psychotherapeutic problems.
<b>1992</b>	Dalen, K., Dr. philos.	Hemispheric asymmetry and the Dual-Task Paradigm: An experimental approach.
	Bø, I.B., Dr. philos.	Ungdoms sosiale økologi. En undersøkelse av 14-16 åringers sosiale nettverk.
	Nivison, M.E., Dr. philos.	The relationship between noise as an experimental and environmental stressor, physiological changes and psychological factors.
	Torgersen, A.M., Dr. philos.	Genetic and environmental influence on temperamental behaviour. A longitudinal study of twins from infancy to adolescence.
<b>1993</b>	Larsen, S., Dr. philos.	Cultural background and problem drinking.
	Nordhus, I.H., Dr. philos.	Family caregiving. A community psychological study with special emphasis on clinical interventions.
	Thuen, F., Dr. psychol.	Accident-related behaviour among children and young adolescents: Prediction and prevention.
	Solheim, R., Dr. philos.	Spesifikke lærevansker. Diskrepanskriteriet anvendt i seleksjonsmetodikk.
	Johnsen, B.H., Dr. psychol.	Brain asymmetry and facial emotional expressions: Conditioning experiments.
<b>1994</b>	Tønnessen, F.E., Dr. philos.	The etiology of Dyslexia.
	Kvale, G., Dr. psychol.	Psychological factors in anticipatory nausea and vomiting in cancer chemotherapy.

	Asbjørnsen, A.E., Dr. psychol.	Structural and dynamic factors in dichotic listening: An interactional model.
	Bru, E., Dr. philos.	The role of psychological factors in neck, shoulder and low back pain among female hospitale staff.
	Braathen, E.T., Dr. psychol.	Prediction of exellence and discontinuation in different types of sport: The significance of motivation and EMG.
	Johannessen, B.F., Dr. philos.	Det flytende kjønnnet. Om lederskap, politikk og identitet.
<b>1995</b>	Sam, D.L., Dr. psychol.	Acculturation of young immigrants in Norway: A psychological and socio-cultural adaptation.
	Bjaalid, I.-K., Dr. philos	Component processes in word recognition.
	Martinsen, Ø., Dr. philos.	Cognitive style and insight.
	Nordby, H., Dr. philos.	Processing of auditory deviant events: Mismatch negativity of event-related brain potentials.
	Raaheim, A., Dr. philos.	Health perception and health behaviour, theoretical considerations, empirical studies, and practical implications.
	Seltzer, W.J., Dr.philos.	Studies of Psychocultural Approach to Families in Therapy.
	Brun, W., Dr.philos.	Subjective conceptions of uncertainty and risk.
	Aas, H.N., Dr. psychol.	Alcohol expectancies and socialization: Adolescents learning to drink.
	Bjørkly, S., Dr. psychol.	Diagnosis and prediction of intra-institutional aggressive behaviour in psychotic patients
<b>1996</b>	Anderssen, Norman, Dr. psychol.	Physical activity of young people in a health perspective: Stability, change and social influences.
	Sandal, Gro Mjeldheim, Dr. psychol.	Coping in extreme environments: The role of personality.
	Strumse, Einar, Dr. philos.	The psychology of aesthetics: explaining visual preferences for agrarian landscapes in Western Norway.
	Hestad, Knut, Dr. philos.	Neuropsychological deficits in HIV-1 infection.
	Lugoe, L.Wycliffe, Dr. philos.	Prediction of Tanzanian students' HIV risk and preventive behaviours
	Sandvik, B. Gunnhild, Dr. philos.	Fra distriktsjordmor til institusjonsjordmor. Fremveksten av en profesjon og en profesjonsutdanning
	Lie, Gro Therese, Dr. psychol.	The disease that dares not speak its name: Studies on factors of importance for coping with HIV/AIDS in Northern Tanzania
	Øygaard, Lisbet, Dr. philos.	Health behaviors among young adults. A psychological and sociological approach
	Stormark, Kjell Morten, Dr. psychol.	Emotional modulation of selective attention: Experimental and clinical evidence.

	Einarsen, Ståle, Dr. psychol.	Bullying and harassment at work: epidemiological and psychosocial aspects.
<b>1997</b>	Knivsberg, Ann-Mari, Dr. philos.	Behavioural abnormalities and childhood psychopathology: Urinary peptide patterns as a potential tool in diagnosis and remediation.
	Eide, Arne H., Dr. philos.	Adolescent drug use in Zimbabwe. Cultural orientation in a global-local perspective and use of psychoactive substances among secondary school students.
	Sørensen, Marit, Dr. philos.	The psychology of initiating and maintaining exercise and diet behaviour.
	Skjæveland, Oddvar, Dr. psychol.	Relationships between spatial-physical neighborhood attributes and social relations among neighbors.
	Zewdie, Tekla, Dr. philos.	Mother-child relational patterns in Ethiopia. Issues of developmental theories and intervention programs.
	Wilhelmsen, Britt Unni, Dr. philos.	Development and evaluation of two educational programmes designed to prevent alcohol use among adolescents.
	Manger, Terje, Dr. philos.	Gender differences in mathematical achievement among Norwegian elementary school students.
<b>1998</b>	Lindstrøm, Torill Christine, Dr. philos.	«Good Grief»: Adapting to Bereavement.
<b>V</b>	Skogstad, Anders, Dr. philos.	Effects of leadership behaviour on job satisfaction, health and efficiency.
	Haldorsen, Ellen M. Håland, Dr. psychol.	Return to work in low back pain patients.
	Besemer, Susan P., Dr. philos.	Creative Product Analysis: The Search for a Valid Model for Understanding Creativity in Products.
<b>H</b>	Winje, Dagfinn, Dr. psychol.	Psychological adjustment after severe trauma. A longitudinal study of adults' and children's posttraumatic reactions and coping after the bus accident in Måbødalen, Norway 1988.
	Vosburg, Suzanne K., Dr. philos.	The effects of mood on creative problem solving.
	Eriksen, Hege R., Dr. philos.	Stress and coping: Does it really matter for subjective health complaints?
	Jakobsen, Reidar, Dr. psychol.	Empiriske studier av kunnskap og holdninger om hiv/aids og den normative seksuelle utvikling i ungdomsårene.
<b>1999</b>	Mikkelsen, Aslaug, Dr. philos.	Effects of learning opportunities and learning climate on occupational health.
<b>V</b>	Samdal, Oddrun, Dr. philos.	The school environment as a risk or resource for students' health-related behaviours and subjective well-being.
	Friestad, Christine, Dr. philos.	Social psychological approaches to smoking.
	Ekeland, Tor-Johan, Dr. philos.	Meining som medisin. Ein analyse av placebofenomenet og implikasjoner for terapi og terapeutiske teoriar.

<b>H</b>	Saban, Sara, Dr. psychol.	Brain Asymmetry and Attention: Classical Conditioning Experiments.
	Carlsten, Carl Thomas, Dr. philos.	God lesing – God læring. En aksjonsrettet studie av undervisning i fagtekstlesing.
	Dundas, Ingrid, Dr. psychol.	Functional and dysfunctional closeness. Family interaction and children's adjustment.
	Engen, Liv, Dr. philos.	Kartlegging av leseferdighet på småskoletrinnet og vurdering av faktorer som kan være av betydning for optimal leseutvikling.
<b>2000 V</b>	Hovland, Ole Johan, Dr. philos.	Transforming a self-preserving "alarm" reaction into a self-defeating emotional response: Toward an integrative approach to anxiety as a human phenomenon.
	Lillejord, Sølvi, Dr. philos.	Handlingsrasjonalitet og spesialundervisning. En analyse av aktørperspektiver.
	Sandell, Ove, Dr. philos.	Den varme kunnskapen.
	Oftedal, Marit Petersen, Dr. philos.	Diagnostisering av ordavkodingsvansker: En prosessanalytisk tilnæringsmåte.
<b>H</b>	Sandbak, Tone, Dr. psychol.	Alcohol consumption and preference in the rat: The significance of individual differences and relationships to stress pathology
	Eid, Jarle, Dr. psychol.	Early predictors of PTSD symptom reporting; The significance of contextual and individual factors.
<b>2001 V</b>	Skinstad, Anne Helene, Dr. philos.	Substance dependence and borderline personality disorders.
	Binder, Per-Einar, Dr. psychol.	Individet og den meningsbærende andre. En teoretisk undersøkelse av de mellommenneskelige forutsetningene for psykisk liv og utvikling med utgangspunkt i Donald Winnicotts teori.
	Roald, Ingvild K., Dr. philos.	Building of concepts. A study of Physics concepts of Norwegian deaf students.
<b>H</b>	Fekadu, Zelalem W., Dr. philos.	Predicting contraceptive use and intention among a sample of adolescent girls. An application of the theory of planned behaviour in Ethiopian context.
	Melesse, Fantu, Dr. philos.	The more intelligent and sensitive child (MISC) mediational intervention in an Ethiopian context: An evaluation study.
	Råheim, Målfrid, Dr. philos.	Kvinnerns kroppserfaring og livssammenheng. En fenomenologisk – hermeneutisk studie av friske kvinner og kvinner med kroniske muskelsmerter.
	Engelsen, Birthe Kari, Dr. psychol.	Measurement of the eating problem construct.
	Lau, Bjørn, Dr. philos.	Weight and eating concerns in adolescence.
<b>2002 V</b>	Ihlebak, Camilla, Dr. philos.	Epidemiological studies of subjective health complaints.



	Rosén, Gunnar O. R., Dr. philos.	The phantom limb experience. Models for understanding and treatment of pain with hypnosis.
	Høines, Marit Johnsen, Dr. philos.	Fleksible språkrom. Matematikklæring som tekstutvikling.
	Anthun, Roald Andor, Dr. philos.	School psychology service quality. Consumer appraisal, quality dimensions, and collaborative improvement potential
	Pallesen, Ståle, Dr. psychol.	Insomnia in the elderly. Epidemiology, psychological characteristics and treatment.
	Midthassel, Unni Vere, Dr. philos.	Teacher involvement in school development activity. A study of teachers in Norwegian compulsory schools
	Kallestad, Jan Helge, Dr. philos.	Teachers, schools and implementation of the Olweus Bullying Prevention Program.
<b>H</b>	Ofte, Sonja Helgesen, Dr. psychol.	Right-left discrimination in adults and children.
	Netland, Marit, Dr. psychol.	Exposure to political violence. The need to estimate our estimations.
	Diseth, Åge, Dr. psychol.	Approaches to learning: Validity and prediction of academic performance.
	Bjuland, Raymond, Dr. philos.	Problem solving in geometry. Reasoning processes of student teachers working in small groups: A dialogical approach.
<b>2003</b> <b>V</b>	Arefjord, Kjersti, Dr. psychol.	After the myocardial infarction – the wives' view. Short- and long-term adjustment in wives of myocardial infarction patients.
	Ingjaldsson, Jón Þorvaldur, Dr. psychol.	Unconscious Processes and Vagal Activity in Alcohol Dependency.
	Holden, Børge, Dr. philos.	Følger av atferdsanalytiske forklaringer for atferdsanalysens tilnærming til utforming av behandling.
	Holsen, Ingrid, Dr. philos.	Depressed mood from adolescence to 'emerging adulthood'. Course and longitudinal influences of body image and parent-adolescent relationship.
	Hammar, Åsa Karin, Dr. psychol.	Major depression and cognitive dysfunction- An experimental study of the cognitive effort hypothesis.
	Sprugevica, Ieva, Dr. philos.	The impact of enabling skills on early reading acquisition.
	Gabrielsen, Egil, Dr. philos.	LESE FOR LIVET. Lesekompetansen i den norske voksenbefolkningen sett i lys av visjonen om en enhetsskole.
<b>H</b>	Hansen, Anita Lill, Dr. psychol.	The influence of heart rate variability in the regulation of attentional and memory processes.
	Dyregrov, Kari, Dr. philos.	The loss of child by suicide, SIDS, and accidents: Consequences, needs and provisions of help.
<b>2004</b> <b>V</b>	Torsheim, Torbjørn, Dr. psychol.	Student role strain and subjective health complaints: Individual, contextual, and longitudinal perspectives.

	Haugland, Bente Storm Mowatt Dr. psychol.	Parental alcohol abuse. Family functioning and child adjustment.
	Milde, Anne Marita, Dr. psychol.	Ulcerative colitis and the role of stress. Animal studies of psychobiological factors in relationship to experimentally induced colitis.
	Stornes, Tor, Dr. philos.	Socio-moral behaviour in sport. An investigation of perceptions of sportspersonship in handball related to important factors of socio-moral influence.
	Mæhle, Magne, Dr. philos.	Re-inventing the child in family therapy: An investigation of the relevance and applicability of theory and research in child development for family therapy involving children.
	Kobbeltvedt, Therese, Dr. psychol.	Risk and feelings: A field approach.
<b>2004</b>	Thomsen, Tormod, Dr. psychol.	Localization of attention in the brain.
<b>H</b>	Løberg, Else-Marie, Dr. psychol.	Functional laterality and attention modulation in schizophrenia: Effects of clinical variables.
	Kyrkjebø, Jane Mikkelsen, Dr. philos.	Learning to improve: Integrating continuous quality improvement learning into nursing education.
	Laumann, Karin, Dr. psychol.	Restorative and stress-reducing effects of natural environments: Experiential, behavioural and cardiovascular indices.
	Holgensen, Helge, PhD	Mellom oss - Essay i relasjonell psykoanalyse.
<b>2005</b>	Hetland, Hilde, Dr. psychol.	Leading to the extraordinary? Antecedents and outcomes of transformational leadership.
<b>V</b>	Iversen, Anette Christine, Dr. philos.	Social differences in health behaviour: the motivational role of perceived control and coping.
<b>2005</b>	Mathisen, Gro Ellen, PhD	Climates for creativity and innovation: Definitions, measurement, predictors and consequences.
<b>H</b>	Sævi, Tone, Dr. philos.	Seeing disability pedagogically – The lived experience of disability in the pedagogical encounter.
	Wiiium, Nora, PhD	Intrapersonal factors, family and school norms: combined and interactive influence on adolescent smoking behaviour.
	Kanagaratnam, Pushpa, PhD	Subjective and objective correlates of Posttraumatic Stress in immigrants/refugees exposed to political violence.
	Larsen, Torill M. B. , PhD	Evaluating principals` and teachers` implementation of Second Step. A case study of four Norwegian primary schools.
	Bancila, Delia, PhD	Psychosocial stress and distress among Romanian adolescents and adults.
<b>2006</b>	Hillestad, Torgeir Martin, Dr. philos.	Normalitet og avvik. Forutsetninger for et objektivt psykopatologisk avviksbegrep. En psykologisk, sosial, erkjennelsesteoretisk og teorihistorisk framstilling.
<b>V</b>		

	Nordanger, Dag Øystein, Dr. psychol.	Psychosocial discourses and responses to political violence in post-war Tigray, Ethiopia.
	Rimol, Lars Morten, PhD	Behavioral and fMRI studies of auditory laterality and speech sound processing.
	Krumsvik, Rune Johan, Dr. philos.	ICT in the school. ICT-initiated school development in lower secondary school.
	Norman, Elisabeth, Dr. psychol.	Gut feelings and unconscious thought: An exploration of fringe consciousness in implicit cognition.
	Israel, K Pravin, Dr. psychol.	Parent involvement in the mental health care of children and adolescents. Empirical studies from clinical care setting.
	Glasø, Lars, PhD	Affects and emotional regulation in leader-subordinate relationships.
	Knutsen, Ketil, Dr. philos.	HISTORIER UNGDOM LEVER – En studie av hvordan ungdommer bruker historie for å gjøre livet meningsfullt.
	Matthiesen, Stig Berge, PhD	Bullying at work. Antecedents and outcomes.
<b>2006</b>	Gramstad, Arne, PhD	Neuropsychological assessment of cognitive and emotional functioning in patients with epilepsy.
<b>H</b>	Bendixen, Mons, PhD	Antisocial behaviour in early adolescence: Methodological and substantive issues.
	Mrumbi, Khalifa Maulid, PhD	Parental illness and loss to HIV/AIDS as experienced by AIDS orphans aged between 12-17 years from Temeke District, Dar es Salaam, Tanzania: A study of the children's psychosocial health and coping responses.
	Hetland, Jørn, Dr. psychol.	The nature of subjective health complaints in adolescence: Dimensionality, stability, and psychosocial predictors
	Kakoko, Deodatus Conatus Vitalis, PhD	Voluntary HIV counselling and testing service uptake among primary school teachers in Mwanza, Tanzania: assessment of socio-demographic, psychosocial and socio-cognitive aspects
	Mykletun, Arnstein, Dr. psychol.	Mortality and work-related disability as long-term consequences of anxiety and depression: Historical cohort designs based on the HUNT-2 study
	Sivertsen, Børge, PhD	Insomnia in older adults. Consequences, assessment and treatment.
<b>2007</b>	Singhammer, John, Dr. philos.	Social conditions from before birth to early adulthood – the influence on health and health behaviour
<b>V</b>	Janvin, Carmen Ani Cristea, PhD	Cognitive impairment in patients with Parkinson's disease: profiles and implications for prognosis
	Braarud, Hanne Cecilie, Dr. psychol.	Infant regulation of distress: A longitudinal study of transactions between mothers and infants
	Tveito, Torill Helene, PhD	Sick Leave and Subjective Health Complaints

	Magnussen, Liv Heide, PhD	Returning disability pensioners with back pain to work
	Thuen, Elin Marie, Dr.philos.	Learning environment, students' coping styles and emotional and behavioural problems. A study of Norwegian secondary school students.
	Solberg, Ole Asbjørn, PhD	Peacekeeping warriors – A longitudinal study of Norwegian peacekeepers in Kosovo
<b>2007</b>	Søreide, Gunn Elisabeth, Dr.philos.	Narrative construction of teacher identity
<b>H</b>	Svensen, Erling, PhD	WORK & HEALTH. Cognitive Activation Theory of Stress applied in an organisational setting.
	Øverland, Simon Nygaard, PhD	Mental health and impairment in disability benefits. Studies applying linkages between health surveys and administrative registries.
	Eichele, Tom, PhD	Electrophysiological and Hemodynamic Correlates of Expectancy in Target Processing
	Børhaug, Kjetil, Dr.philos.	Oppseding til demokrati. Ein studie av politisk oppseding i norsk skule.
	Eikeland, Thorleif, Dr.philos.	Om å vokse opp på barnehjem og på sykehus. En undersøkelse av barnehjemsbarns opplevelser på barnehjem sammenholdt med sanatoriebarns beskrivelse av langvarige sykehusopphold – og et forsøk på forklaring.
	Wadel, Carl Cato, Dr.philos.	Medarbeidersamhandling og medarbeiderledelse i en lagbasert organisasjon
	Vinje, Hege Forbech, PhD	Thriving despite adversity: Job engagement and self-care among community nurses
	Noort, Maurits van den, PhD	Working memory capacity and foreign language acquisition
<b>2008</b>	Breivik, Kyrre, Dr.psychol.	The Adjustment of Children and Adolescents in Different Post-Divorce Family Structures. A Norwegian Study of Risks and Mechanisms.
<b>V</b>	Johnsen, Grethe E., PhD	Memory impairment in patients with posttraumatic stress disorder
	Sætrevik, Bjørn, PhD	Cognitive Control in Auditory Processing
	Carvalho, Susana Fonseca, PhD	Prevention of bullying in schools: an ecological model
<b>2008</b>	Brønnick, Kolbjørn Selvåg	Attentional dysfunction in dementia associated with Parkinson's disease.
<b>H</b>	Posserud, Maj-Britt Rocio	Epidemiology of autism spectrum disorders
	Haug, Ellen	Multilevel correlates of physical activity in the school setting
	Skjerve, Arvid	Assessing mild dementia – a study of brief cognitive tests.

	Kjønniksen, Lise	The association between adolescent experiences in physical activity and leisure time physical activity in adulthood: a ten year longitudinal study
	Gundersen, Hilde	The effects of alcohol and expectancy on brain function
	Omvik, Siri	Insomnia – a night and day problem
<b>2009 V</b>	Molde, Helge	Pathological gambling: prevalence, mechanisms and treatment outcome.
	Foss, Else	Den omsorgsfulle væremåte. En studie av voksnes væremåte i forhold til barn i barnehagen.
	Westrheim, Kariane	Education in a Political Context: A study of Knowledge Processes and Learning Sites in the PKK.
	Wehling, Eike	Cognitive and olfactory changes in aging
	Wangberg, Silje C.	Internet based interventions to support health behaviours: The role of self-efficacy.
	Nielsen, Morten B.	Methodological issues in research on workplace bullying. Operationalisations, measurements and samples.
	Sandu, Anca Larisa	MRI measures of brain volume and cortical complexity in clinical groups and during development.
	Guribye, Eugene	Refugees and mental health interventions
	Sørensen, Lin	Emotional problems in inattentive children – effects on cognitive control functions.
	Tjomsland, Hege E.	Health promotion with teachers. Evaluation of the Norwegian Network of Health Promoting Schools: Quantitative and qualitative analyses of predisposing, reinforcing and enabling conditions related to teacher participation and program sustainability.
	Helleve, Ingrid	Productive interactions in ICT supported communities of learners
<b>2009 H</b>	Skorpen, Aina Øye, Christine	Dagliglivet i en psykiatrisk institusjon: En analyse av miljøterapeutiske praksiser
	Andreassen, Cecilie Schou	WORKAHOLISM – Antecedents and Outcomes
	Stang, Ingun	Being in the same boat: An empowerment intervention in breast cancer self-help groups
	Sequeira, Sarah Dorothee Dos Santos	The effects of background noise on asymmetrical speech perception
	Kleiven, Jo, dr.philos.	The Lillehammer scales: Measuring common motives for vacation and leisure behavior
	Jónsdóttir, Guðrún	Dubito ergo sum? Ni jenter møter naturfaglig kunnskap.
	Hove, Oddbjørn	Mental health disorders in adults with intellectual disabilities - Methods of assessment and prevalence of mental health disorders and problem behaviour
	Wageningen, Heidi Karin van	The role of glutamate on brain function

	Bjørkvik, Jofrid	God nok? Selvaktelse og interpersonlig fungering hos pasienter innen psykisk helsevern: Forholdet til diagnoser, symptomer og behandlingsutbytte
	Andersson, Martin	A study of attention control in children and elderly using a forced-attention dichotic listening paradigm
	Almås, Aslaug Grov	Teachers in the Digital Network Society: Visions and Realities. A study of teachers' experiences with the use of ICT in teaching and learning.
	Ulvik, Marit	Lærerutdanning som dannning? Tre stemmer i diskusjonen
<b>2010</b>	Skår, Randi	Læringsprosesser i sykepleieres profesjonsutøvelse. En studie av sykepleieres læringserfaringer.
<b>V</b>	Roald, Knut	Kvalitetsvurdering som organisasjonslæring mellom skole og skoleeigar
	Lunde, Linn-Heidi	Chronic pain in older adults. Consequences, assessment and treatment.
	Danielsen, Anne Grete	Perceived psychosocial support, students' self-reported academic initiative and perceived life satisfaction
	Hysing, Mari	Mental health in children with chronic illness
	Olsen, Olav Kjellevoid	Are good leaders moral leaders? The relationship between effective military operational leadership and morals
	Riese, Hanne	Friendship and learning. Entrepreneurship education through mini-enterprises.
	Holthe, Asle	Evaluating the implementation of the Norwegian guidelines for healthy school meals: A case study involving three secondary schools
<b>H</b>	Hauge, Lars Johan	Environmental antecedents of workplace bullying: A multi-design approach
	Bjørkelo, Brita	Whistleblowing at work: Antecedents and consequences
	Reme, Silje Endresen	Common Complaints – Common Cure? Psychiatric comorbidity and predictors of treatment outcome in low back pain and irritable bowel syndrome
	Helland, Wenche Andersen	Communication difficulties in children identified with psychiatric problems
	Beneventi, Harald	Neuronal correlates of working memory in dyslexia
	Thygesen, Elin	Subjective health and coping in care-dependent old persons living at home
	Aanes, Mette Marthinussen	Poor social relationships as a threat to belongingness needs. Interpersonal stress and subjective health complaints: Mediating and moderating factors.
	Anker, Morten Gustav	Client directed outcome informed couple therapy

	Bull, Torill	Combining employment and child care: The subjective well-being of single women in Scandinavia and in Southern Europe
	Viig, Nina Grieg	Tilrettelegging for læreres deltakelse i helsefremmende arbeid. En kvalitativ og kvantitativ analyse av sammenhengen mellom organisatoriske forhold og læreres deltakelse i utvikling og implementering av Europeisk Nettverk av Helsefremmende Skoler i Norge
	Wolff, Katharina	To know or not to know? Attitudes towards receiving genetic information among patients and the general public.
	Ogden, Terje, dr.philos.	Familiebasert behandling av alvorlige atferdsproblemer blant barn og ungdom. Evaluering og implementering av evidensbaserte behandlingsprogrammer i Norge.
	Solberg, Mona Elin	Self-reported bullying and victimisation at school: Prevalence, overlap and psychosocial adjustment.
<b>2011</b>	Bye, Hege Høivik	Self-presentation in job interviews. Individual and cultural differences in applicant self-presentation during job interviews and hiring managers' evaluation
<b>V</b>	Notelaers, Guy	Workplace bullying. A risk control perspective.
	Moltu, Christian	Being a therapist in difficult therapeutic impasses. A hermeneutic phenomenological analysis of skilled psychotherapists' experiences, needs, and strategies in difficult therapies ending well.
	Myrseth, Helga	Pathological Gambling - Treatment and Personality Factors
	Schanche, Elisabeth	From self-criticism to self-compassion. An empirical investigation of hypothesized change processes in the Affect Phobia Treatment Model of short-term dynamic psychotherapy for patients with Cluster C personality disorders.
	Våpenstad, Eystein Victor, dr.philos.	Det tempererte nærvær. En teoretisk undersøkelse av psykoteraeutens subjektivitet i psykoanalyse og psykoanalytisk psykoterapi.
	Haukebø, Kristin	Cognitive, behavioral and neural correlates of dental and intra-oral injection phobia. Results from one treatment and one fMRI study of randomized, controlled design.
	Harris, Anette	Adaptation and health in extreme and isolated environments. From 78°N to 75°S.
	Bjørknes, Ragnhild	Parent Management Training-Oregon Model: intervention effects on maternal practice and child behavior in ethnic minority families
	Mamen, Asgeir	Aspects of using physical training in patients with substance dependence and additional mental distress
	Espevik, Roar	Expert teams: Do shared mental models of team members make a difference
	Haara, Frode Olav	Unveiling teachers' reasons for choosing practical activities in mathematics teaching

<b>2011</b>	Hauge, Hans Abraham	How can employee empowerment be made conducive to both employee health and organisation performance? An empirical investigation of a tailor-made approach to organisation learning in a municipal public service organisation.
<b>H</b>	Melkevik, Ole Rogstad	Screen-based sedentary behaviours: pastimes for the poor, inactive and overweight? A cross-national survey of children and adolescents in 39 countries.
	Vøllestad, Jon	Mindfulness-based treatment for anxiety disorders. A quantitative review of the evidence, results from a randomized controlled trial, and a qualitative exploration of patient experiences.
	Tolo, Astrid	Hvordan blir lærerkompetanse konstruert? En kvalitativ studie av PPU-studenters kunnskapsutvikling.
	Saus, Evelyn-Rose	Training effectiveness: Situation awareness training in simulators
	Nordgreen, Tine	Internet-based self-help for social anxiety disorder and panic disorder. Factors associated with effect and use of self-help.
	Munkvold, Linda Helen	Oppositional Defiant Disorder: Informant discrepancies, gender differences, co-occurring mental health problems and neurocognitive function.
	Christiansen, Øivin	Når barn plasseres utenfor hjemmet: beslutninger, forløp og relasjoner. Under barnevernets (ved)tak.
	Brunborg, Geir Scott	Conditionability and Reinforcement Sensitivity in Gambling Behaviour
	Hystad, Sigurd William	Measuring Psychological Resiliency: Validation of an Adapted Norwegian Hardiness Scale
<b>2012</b>	Roness, Dag	Hvorfor bli lærer? Motivasjon for utdanning og utøving.
<b>V</b>	Fjermestad, Krister Westlye	The therapeutic alliance in cognitive behavioural therapy for youth anxiety disorders
	Jenssen, Eirik Sørnes	Tilpasset opplæring i norsk skole: politikeres, skolelederes og læreres handlingsvalg
	Saksvik-Lehouillier, Ingvild	Shift work tolerance and adaptation to shift work among offshore workers and nurses
	Johansen, Venke Frederike	Når det intime blir offentlig. Om kvinners åpenhet om brystkreft og om markedsføring av brystkreftsaken.
	Herheim, Rune	Pupils collaborating in pairs at a computer in mathematics learning: investigating verbal communication patterns and qualities
	Vie, Tina Løkke	Cognitive appraisal, emotions and subjective health complaints among victims of workplace bullying: A stress-theoretical approach
	Jones, Lise Øen	Effects of reading skills, spelling skills and accompanying efficacy beliefs on participation in education. A study in Norwegian prisons.



<b>2012</b> <b>H</b>	Danielsen, Yngvild Sørebo	Childhood obesity – characteristics and treatment. Psychological perspectives.
	Horverak, Jøri Gytre	Sense or sensibility in hiring processes. Interviewee and interviewer characteristics as antecedents of immigrant applicants' employment probabilities. An experimental approach.
	Jøsendal, Ola	Development and evaluation of BE smokeFREE, a school-based smoking prevention program
	Osnes, Berge	Temporal and Posterior Frontal Involvement in Auditory Speech Perception
	Drageset, Sigrunn	Psychological distress, coping and social support in the diagnostic and preoperative phase of breast cancer
	Aasland, Merethe Schanke	Destructive leadership: Conceptualization, measurement, prevalence and outcomes
	Bakibinga, Pauline	The experience of job engagement and self-care among Ugandan nurses and midwives
	Skogen, Jens Christoffer	Foetal and early origins of old age health. Linkage between birth records and the old age cohort of the Hordaland Health Study (HUSK)
	Leveresen, Ingrid	Adolescents' leisure activity participation and their life satisfaction: The role of demographic characteristics and psychological processes
	Hanss, Daniel	Explaining sustainable consumption: Findings from cross-sectional and intervention approaches
Rød, Per Arne	Barn i klem mellom foreldrekonflikter og samfunnsmessig beskyttelse	
<b>2013</b> <b>V</b>	Mentzoni, Rune Aune	Structural Characteristics in Gambling
	Knudsen, Ann Kristin	Long-term sickness absence and disability pension award as consequences of common mental disorders. Epidemiological studies using a population-based health survey and official ill health benefit registries.
	Strand, Mari	Emotional information processing in recurrent MDD
	Veseth, Marius	Recovery in bipolar disorder. A reflexive-collaborative exploration of the lived experiences of healing and growth when battling a severe mental illness
	Mæland, Silje	Sick leave for patients with severe subjective health complaints. Challenges in general practice.
	Mjaaland, Thera	At the frontiers of change? Women and girls' pursuit of education in north-western Tigray, Ethiopia
	Odéen, Magnus	Coping at work. The role of knowledge and coping expectancies in health and sick leave.
	Hynninen, Kia Minna Johanna	Anxiety, depression and sleep disturbance in chronic obstructive pulmonary disease (COPD). Associations, prevalence and effect of psychological treatment.

	Flo, Elisabeth	Sleep and health in shift working nurses
	Aasen, Elin Margrethe	From paternalism to patient participation? The older patients undergoing hemodialysis, their next of kin and the nurses: a discursive perspective on perception of patient participation in dialysis units
	Ekornås, Belinda	Emotional and Behavioural Problems in Children: Self-perception, peer relationships, and motor abilities
	Corbin, J. Hope	North-South Partnerships for Health: Key Factors for Partnership Success from the Perspective of the KIWAKKUKI
	Birkeland, Marianne Skogbrott	Development of global self-esteem: The transition from adolescence to adulthood
<b>2013</b>	Gianella-Malca, Camila	Challenges in Implementing the Colombian Constitutional Court's Health-Care System Ruling of 2008
<b>H</b>	Hovland, Anders	Panic disorder – Treatment outcomes and psychophysiological concomitants
	Mortensen, Øystein	The transition to parenthood – Couple relationships put to the test
	Årdal, Guro	Major Depressive Disorder – a Ten Year Follow-up Study. Inhibition, Information Processing and Health Related Quality of Life
	Johansen, Rino Bandlitz	The impact of military identity on performance in the Norwegian armed forces
	Bøe, Tormod	Socioeconomic Status and Mental Health in Children and Adolescents
<b>2014</b>	Nordmo, Ivar	Gjennom nåløyet – studenters læringserfaringer i psykologutdanningen
<b>V</b>	Dovran, Anders	Childhood Trauma and Mental Health Problems in Adult Life
	Hegelstad, Wenche ten Velden	Early Detection and Intervention in Psychosis: A Long-Term Perspective
	Urheim, Ragnar	Forståelse av pasientaggresjon og forklaringer på nedgang i voldsrater ved Regional sikkerhetsavdeling, Sandviken sykehus
	Kinn, Liv Grethe	Round-Trips to Work. Qualitative studies of how persons with severe mental illness experience work integration.
	Rød, Anne Marie Kinn	Consequences of social defeat stress for behaviour and sleep. Short-term and long-term assessments in rats.
	Nygård, Merethe	Schizophrenia – Cognitive Function, Brain Abnormalities, and Cannabis Use
	Tjora, Tore	Smoking from adolescence through adulthood: the role of family, friends, depression and socioeconomic status. Predictors of smoking from age 13 to 30 in the "The Norwegian Longitudinal Health Behaviour Study" (NLHB)
	Vangsnes, Vigdis	The Dramaturgy and Didactics of Computer Gaming. A Study of a Medium in the Educational Context of Kindergartens.

	Nordahl, Kristin Berg	Early Father-Child Interaction in a Father-Friendly Context: Gender Differences, Child Outcomes, and Protective Factors related to Fathers' Parenting Behaviors with One-year-olds
<b>2014</b>	Sandvik, Asle Makoto	Psychopathy – the heterogeneity of the construct
<b>H</b>	Skotheim, Siv	Maternal emotional distress and early mother-infant interaction: Psychological, social and nutritional contributions
	Halleland, Helene Barone	Executive Functioning in adult Attention Deficit Hyperactivity Disorder (ADHD). From basic mechanisms to functional outcome.
	Halvorsen, Kirsti Vindal	Partnerskap i lærerutdanning, sett fra et økologisk perspektiv
	Solbue, Vibeke	Dialogen som visker ut kategorier. En studie av hvilke erfaringer innvandererungdommer og norskfødte med innvanderforeldre har med videregående skole. Hva forteller ungdommenes erfaringer om videregående skoles håndtering av etniske ulikheter?
	Kvalevaag, Anne Lise	Fathers' mental health and child development. The predictive value of fathers' psychological distress during pregnancy for the social, emotional and behavioural development of their children
	Sandal, Ann Karin	Ungdom og utdanningsval. Om elevar sine opplevingar av val og overgangsprossessar.
	Haug, Thomas	Predictors and moderators of treatment outcome from high- and low-intensity cognitive behavioral therapy for anxiety disorders. Association between patient and process factors, and the outcome from guided self-help, stepped care, and face-to-face cognitive behavioral therapy.
	Sjølie, Hege	Experiences of Members of a Crisis Resolution Home Treatment Team. Personal history, professional role and emotional support in a CRHT team.
	Falkenberg, Liv Eggset	Neuronal underpinnings of healthy and dysfunctional cognitive control
	Mrdalj, Jelena	The early life condition. Importance for sleep, circadian rhythmicity, behaviour and response to later life challenges
	Hesjedal, Elisabeth	Tverrprofesjonelt samarbeid mellom skule og barnevern: Kva kan støtte utsette barn og unge?
<b>2015</b>	Hauken, May Aasebø	« <i>The cancer treatment was only half the work!</i> » A Mixed-Method Study of Rehabilitation among Young Adult Cancer Survivors
<b>V</b>	Ryland, Hilde Katrin	Social functioning and mental health in children: the influence of chronic illness and intellectual function
	Rønsen, Anne Kristin	Vurdering som profesjonskompetanse. Refleksjonsbasert utvikling av læreres kompetanse i formativ vurdering

	Hoff, Helge Andreas	Thinking about Symptoms of Psychopathy in Norway: Content Validation of the Comprehensive Assessment of Psychopathic Personality (CAPP) Model in a Norwegian Setting
	Schmid, Marit Therese	Executive Functioning in recurrent- and first episode Major Depressive Disorder. Longitudinal studies
	Sand, Liv	Body Image Distortion and Eating Disturbances in Children and Adolescents
	Matanda, Dennis Juma	Child physical growth and care practices in Kenya: Evidence from Demographic and Health Surveys
	Amugsi, Dickson Abanimi	Child care practices, resources for care, and nutritional outcomes in Ghana: Findings from Demographic and Health Surveys
	Jakobsen, Hilde	The good beating: Social norms supporting men's partner violence in Tanzania
	Sagoe, Dominic	Nonmedical anabolic-androgenic steroid use: Prevalence, attitudes, and social perception
	Eide, Helene Marie Kjærgård	Narrating the relationship between leadership and learning outcomes. A study of public narratives in the Norwegian educational sector.
<b>2015</b>	Wubs, Annegreet Gera	Intimate partner violence among adolescents in South Africa and Tanzania
<b>H</b>	Hjelmervik, Helene Susanne	Sex and sex-hormonal effects on brain organization of fronto-parietal networks
	Dahl, Berit Misund	The meaning of professional identity in public health nursing
	Røykenes, Kari	Testangst hos sykepleierstudenter: «Alternativ behandling»
	Bless, Josef Johann	The smartphone as a research tool in psychology. Assessment of language lateralization and training of auditory attention.
	Løvvik, Camilla Margrethe Sigvaldsen	Common mental disorders and work participation – the role of return-to-work expectations
	Lehmann, Stine	Mental Disorders in Foster Children: A Study of Prevalence, Comorbidity, and Risk Factors
	Knapstad, Marit	Psychological factors in long-term sickness absence: the role of shame and social support. Epidemiological studies based on the Health Assets Project.
<b>2016</b>	Kvestad, Ingrid	Biological risks and neurodevelopment in young North Indian children
<b>V</b>	Sælør, Knut Tore	Hinderløyper, halmstrå og hengende snører. En kvalitativ studie av håp innenfor psykisk helse- og rusfeltet.
	Mellingen, Sonja	Alkoholbruk, partilfredshet og samlivsstatus. Før, inn i, og etter svangerskapet – korrelerer eller konsekvenser?
	Thun, Eirunn	Shift work: negative consequences and protective factors

	Hilt, Line Torbjørnsen	The borderlands of educational inclusion. Analyses of inclusion and exclusion processes for minority language students
	Havnen, Audun	Treatment of obsessive-compulsive disorder and the importance of assessing clinical effectiveness
	Slåtten, Hilde	Gay-related name-calling among young adolescents. Exploring the importance of the context.
	Ree, Eline	Staying at work. The role of expectancies and beliefs in health and workplace interventions.
	Morken, Frøydis	Reading and writing processing in dyslexia
<b>2016</b>	Løvoll, Helga Synnevåg	Inside the outdoor experience. On the distinction between pleasant and interesting feelings and their implication in the motivational process.
<b>H</b>	Hjeltnes, Aslak	Facing social fears: An investigation of mindfulness-based stress reduction for young adults with social anxiety disorder
	Øyeflaten, Irene Larsen	Long-term sick leave and work rehabilitation. Prognostic factors for return to work.
	Henriksen, Roger Ekeberg	Social relationships, stress and infection risk in mother and child
	Johnsen, Iren	«Only a friend» - The bereavement process of young adults who have lost a friend to a traumatic death. A mixed methods study.
	Helle, Siri	Cannabis use in non-affective psychoses: Relationship to age at onset, cognitive functioning and social cognition
	Glabek, Mats	Workplace bullying and expulsion in working life. A representative study addressing prospective associations and explanatory conditions.
	Oanes, Camilla Jensen	Tilbakemelding i terapi. På hvilke måter opplever terapeuter at tilbakemeldingsprosedyrer kan virke inn på terapeutiske praksiser?
	Reknes, Iselin	Exposure to workplace bullying among nurses: Health outcomes and individual coping
	Chimhutu, Victor	Results-Based Financing (RBF) in the health sector of a low-income country. From agenda setting to implementation: The case of Tanzania
	Ness, Ingunn Johanne	The Room of Opportunity. Understanding how knowledge and ideas are constructed in multidisciplinary groups working with developing innovative ideas.
	Hollekim, Ragnhild	Contemporary discourses on children and parenting in Norway. An empirical study based on two cases.
	Doran, Rouven	Eco-friendly travelling: The relevance of perceived norms and social comparison
<b>2017</b>	Katisi, Masego	The power of context in health partnerships: Exploring synergy and antagonism between external and internal ideologies in implementing Safe Male Circumcision (SMC) for HIV prevention in Botswana
<b>V</b>		

	Jamaludin, Nor Lelawati Binti	The “why” and “how” of International Students’ Ambassadorship Roles in International Education
	Berthelsen, Mona	Effects of shift work and psychological and social work factors on mental distress. Studies of onshore/offshore workers and nurses in Norway.
	Krane, Vibeke	Lærer-elev-relasjoner, elevers psykiske helse og frafall i videregående skole – en eksplorerende studie om samarbeid og den store betydningen av de små ting
	Søvik, Margaret Ljosnes	Evaluating the implementation of the Empowering Coaching™ program in Norway
	Tonheim, Milfrid	A troublesome transition: Social reintegration of girl soldiers returning ‘home’
	Senneseth, Mette	Improving social network support for partners facing spousal cancer while caring for minors. A randomized controlled trial.
	Urke, Helga Bjørnøy	Child health and child care of very young children in Bolivia, Colombia and Peru.
	Bakhturidze, George	Public Participation in Tobacco Control Policy-making in Georgia
	Fismen, Anne-Siri	Adolescent eating habits. Trends and socio-economic status.
<b>2017</b>	Hagatun, Susanne	Internet-based cognitive-behavioural therapy for insomnia. A randomised controlled trial in Norway.
<b>H</b>	Eichele, Heike	Electrophysiological Correlates of Performance Monitoring in Children with Tourette Syndrome. A developmental perspective.
	Risan, Ulf Patrick	Accommodating trauma in police interviews. An exploration of rapport in investigative interviews of traumatized victims.