Expertise or Safety Climate? Approaching Human Factors in Demanding Maritime Operations

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Abstract

Our knowledge of the factors that affect safety and performance in complex system becomes outdated as the domain evolves. Increased activity and complexity in maritime offshore operations requires that we update our knowledge on which factors that affects safety and performance in these complex systems. The purpose of this study was to examine to which degree a model of expertise and a model of safety climate were sensitive to account for interview statements from operative marine officers regarding work practices in demanding maritime operation. Semi-structured interviews were conducted on 10 marine officers from anchor handling and tug support vessels (AHTS) and platform supply vessels (PSV). Based on an M-SWOT approach, statements were coded into the categories of each model. The results revealed that neither a model of expertise nor safety climate could alone account for all statements. Together, the chosen models could together account for 61.9 % of the total of 1947 identified statements. Qualitative analysis of the statements not accounted for by either models revealed several meaningful themes regarding work in demanding operations. The results demonstrate a useful insight to the complexity of working in demanding maritime operations and can provide several starting points for further research.

Expertise or Safety Climate? Approaching Human Factors in Demanding Maritime Operations.

After 40 years of successful petroleum industry in Norway it is still expected much activity on the Norwegian continental shelf in the years to come. However, there are many signs of increasing complexity in production (Forskningsrådet, 2010). Recent oil and gas discoveries have been relatively small, and it is expected extraction from many small-scale fields in distant areas. Production on deep water and exploration of the northern areas will require complex subsea operations and challenges related to cold climate and ice. All these aspects will require demanding surface activities and several more anchor handling and tug support vessels (AHTS), more platform supply vessels (PSV), and more specialized construction vessels (Maritim21, 2010).

On April 12, 2007, the multi-purpose / anchor handling vessel *Bourbon Dolphin* capsized northwest of Shetland during an anchor handling operation. Eight lives were lost. The accident report revealed that no single cause could alone explain why this accident was allowed to happen (NOU, 2008: 8). The accident investigation board identified a whole range of undesirable circumstances, from breaches of safety requirements to lack of qualification and experience of the crew. These issues will continue to exist on new vessels unless something is done.

The Bourbon Dolphin accident illustrates the complexity of operating an offshore support vessel. The accident report argued that there is by no means shortage of written materials, both obligatory and advisory, to remain safe. Existing safety measures have clearly failed in the Bourbon Dolphin case, and may thus be seen as a more general feature of safety issues in current oil and gas industries – that our knowledge has not been sufficiently developed as the field has evolved.

The fact is that the maritime industry depends upon experienced and competent personnel to be able to perform safely and efficiently in complex operations in the future. Meanwhile, an increasing complexity in production as well as the highly sophisticated ships will continuously change the way mariners cope and deal with the demands presented to them (Perrow, 1986). Rapid change in equipment and technological interfaces can in fact make it even harder for mariners to operate safely (Bjørkli, 2007; Koester, 2001; Lützhöft, 2004). Lack of sufficient understanding of how mariners perceive their work and cope with the challenges presented to them will leave the industry less capable to adjust to ensure safe and efficient operations in the future as suggested in the Bourbon Dolphin accident report.

In the following I will present some of the challenges related to studying work in complex industries, and then turn to discuss some issues concerning the maritime domain. Furthermore I will debate two perspectives towards understanding the role of the human element in complex maritime operations.

Coping with Complexity – Working in Complex Sociotechnical Systems

The human factors discipline studies the intersection between people, technology and work (Wichkens, Lee, Liu, & Becker, 2004). When this intersection becomes profoundly complex, as it tends to do for high-risk industries such as offshore installations, nuclear power plants, aviation, and health care, they are identified as complex sociotechnical systems (Norros, 2004; Vicente, 2004). Such systems make it possible to control and coordinate large resources, but make them also vulnerable to catastrophic accidents if things go wrong. In a complex sociotechnical system, performance and safety depends upon constant interaction between people and their work environment, i.e. environmental context, the organizational infrastructure and the equipment they use (See for instance Bjørkli, Røed, Bjelland, Gould, & Hoff, 2007).

The shipping industry is without doubt a complex sociotechnical system, and maritime accidents can have potentially devastating consequences (Hetherington, Flin, & Mearns, 2006; Perrow, 1999). The factors that contribute to the complexity of such systems vary, but Vicente (1999) lists a set of dimensions broad enough to subsume most of them. Table 1 lists the dimensions given by Vicente, in addition to some remarks relevant for the offshore maritime domain.

As showed in Table 1, there are several dimensions relevant for operating a marine vessel. The increasing complexity of maritime offshore operations poses unique challenges to the people involved in the design, implementation and maintenance of these systems, but equally important concerns challenges related to the people working there (Carayon, 2006). As work becomes more complex, so do also the task of keeping the system within its limits for safe operation.

Table 1: *Complexity of work systems as presented by Vicente (1999, p. 14)*

Dimensions of complexity	Definition	Maritime relevance
Large problem spaces	Many different elements and forces	Weather, underwater stream, other vessels, etc
Social	Many people who must work together	Officers, deck crew, engineers
Heterogeneous perspectives	Workers with different background and disciplines	Multinational crew, experience from different vessels
Distributed system	Delay in effects of actions	Maneuvering and handling
Hazardous system	Devastating economic, public, social and environmental consequences	Marine accidents and incidents
Coupling	Interacting subsystems	Dynamic positioning, operator, engine, crew on deck etc.
Automation	Automated systems	Autopilot, dynamic positioning, technical equipment
Uncertainty	Uncertainty in data available to workers	Weather, Imperfect sensors, economical drivers
Mediated interaction	Properties that cannot be directly observed	Activities beneath surface, competing companies
Disturbances	Workers dealing with unanticipated events	Sudden change in weather conditions, engine failure

Ensuring Safety and Efficiency – A Matter of Multiple Perspectives

As noted above, human factors studies the intersection between people, technology and work. However, in complex systems, one is also concerned with cross-scale interactions between what Woods and Hollnagel (2006) term the sharp end and the blunt end of an organization. Within a shipping company, the sharp end consist of the people working close to the actual production, in this case the crew on a ship, while the blunt end is represented by the regulators, administrators, economic policy makers, and technology suppliers.

The interactions between different parts of a complex system highlight the problem of risk modeling in dynamic systems as argued by Rasmussen (1997). Rasmussen holds that the problem space for complex sociotechnical systems expands far beyond the organization and its immediate environment. Forces that affect system performance and safety stretches from the society's rules and regulations at the top, down to the smallest equipment used by operators.

For those concerned with making systems safer and more reliable, these cross scale interactions presents a central challenge. How do we identify and isolate the operational organization, and furthermore which unit of analysis would bring relevant knowledge of current affairs? Perrow (1999) pointed out that the role of humans always has been a critical component aboard ships. The international maritime organization (IMO) states that life at sea is highly dependent on competent seafarers (IMO, 2010). However, human behavior is constantly affected by their technical equipment and several organizational factors such as commercial pressure, rules, international regulations and the effects of organizational culture (Barnett, Gatfield, & Pekcan, 2003; Trafford, 2009). As a result, the potential units of analysis could be a whole range of different sources, varying from issues connected to humans at the one side to higher order organizational issues on the other. A consequence of the various starting points is that there is no agreement over which unit of analysis that is most profitable and researchers have to choose wisely. In line with the increasing complexity in the maritime offshore industry, what would be a valuable starting point in a marine context?

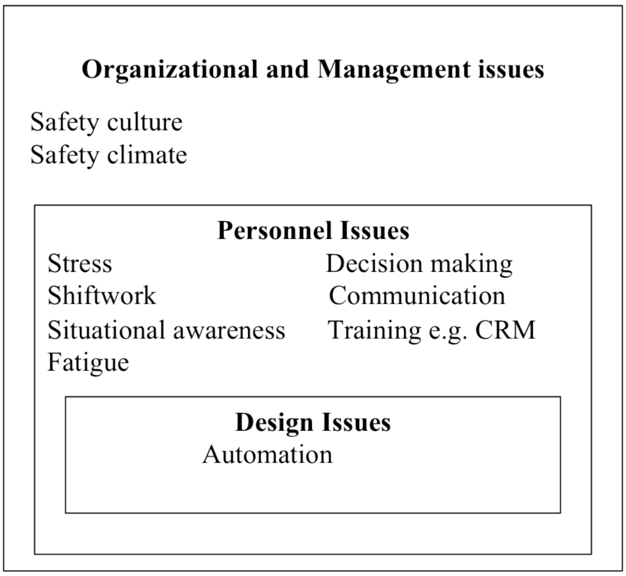
Human Factors in The Maritime Industry

Ship navigation involves a high degree of uncertainty, dynamism and complexity (Norros, 2004). Consequently, the factors that affect safety and performance can be various. Gould, Røed, Koefoed, Bridger and Moen (2006) examined 35 navigation accident in the Royal Norwegian Navy with the aim at identifying factors that influenced the likelihood of an error occurring, also called performing shaping factors (PSF). From the 35 accidents they identified in total 644 PFS. Furthermore, they made a categorization between PFSs that included characteristics of humans, the task, the system, and the environment. This categorization presents a useful insight in some of the main sources of performance variability in naval operations. Within a context of assessing safety and performance, each category could be a fine starting point to start identifying units of analysis. However, naval operations are more isolated from the market forces than commercial shipping. Hence, it might be a different picture in commercial shipping.

Hetherington et al. (2006) conducted a review of 20 various shipping accidents and showed that these accidents also were a matter of multiple factors. Much similar to how

Gould et al. (2006) categorized the different PFSs, Hetherington and colleagues made a conceptual distinction between organizational-, personnel-, and design issues that contributed to accidents, and furthermore also reviewed the most common interventions to make shipping safer in relation to this distinction. Figure 1 presents an illustration of the identified issues.

Figure 1: *An organizing framework for human factors issues that contribute to organizational accidents in shipping. Inspired from Hetherington, Flin, and Mearns (2006).*



The conceptual distinction between organizational, personnel and technical issues, as illustrated in Figure 1 makes some basic assumptions about where the sources of variability and stability exist in a complex system, and furthermore which means that can be taken to obtain better knowledge of these issues. From an organizational perspective, opponents for studying safety climate, for instance, will claim that the management's attitude and behavior towards safety will permeate down trough the organization to the workforce (Guldenmund, 2000). Using measures of safety climate on people working at the sharp end can therefore say something about how the organization is currently thinking about safety and furthermore give some indications on which areas that could receive more attention.

On the other hand, personnel factors such as stress or mental workload could say something about the crew's ability to accomplish their work under given circumstances. Gould et al. (2006) found for instance that the most frequently occurring PSF in naval accidents were related to operator expectation, perceptual demands, attention, and anticipatory requirements. Hence, gathering knowledge of such factors could give researchers some clues of how personnel are reacting to the work demands that is presented to them.

Another way of approaching cognitive limitations can be from a technical point of view that focus on designing better automation equipment and adapt advanced technology to the user. An increase in automation equipment, such as navigation, has among other things changed the manning requirements on modern vessels and has made a huge impact on the way the crew work on a daily basis (Røed, 2007) Due to the scope of this study, I will not go further in discussing design issues. For an elaboration of these matters, see for instance Woods (1998). In the following I will focus on the intervention of personnel and organizational issues, and furthermore discuss some perspectives of how these issues are studied in the maritime domain.

Personnel issues – Identifying Aspects of Human Performance

As shown in Figure 1 and from the study of Gould et al. (2006), personnel issues in the maritime domain can be examined trough a wide range of different approaches. In the end, a personnel-centered approach attempts to identify and explain which conditions the crew is performing well. A common feature of these issues is that they tend to be quite specific. An alternative approach would be to look at a framework that could account for several human performance characteristics at once. To do this, we could turn to the area of expertise.

The concept of expertise is a concept much discussed by human factors practitioners, either implicitly or explicitly, through for instance in relation to analysis of human performance, task analysis, human reliability analysis, in studies of learning and training, and in development of expert systems (such as automation) (Charness & Tuffiash, 2008; Farrington-Darby & Wilson, 2006). Understanding the characteristics of expert performance is therefore central to both design of new work systems as well as how to train and develop competent people.

What is Expertise?

According to Farrington-Darby and Wilson (2006), expertise can refer to description of skills, knowledge or abilities in a certain activity; a process such as decision-making; or it can refer to an output such as a decision. Expertise focus at the characteristics that distinguish experts from novices and an expert can be defined as someone who over time show superior performance in a domain (Ericsson, 2006b; Gruber, 2001). The knowledge of experts is therefore a valuable source of information into what is relevant or necessary to achieve performance. The problem with expert models, however, is that they tend to be very domain specific (Cellier, Eyrolle, & Marine, 1997; Gruber, 2001). As a consequence it is practically impossible to provide a consensual and operational definition of what an expert is, what they know, and how they cope with their respective operational tasks. Three of the most representative domains that have seen extensive research the past few decades are in sports, aviation, and medicine (For a further discussion, see Charness & Tuffiash, 2008).

The area of expertise is a large and complex research area. The scope of this study does not give room for a comprehensive overview of the various concepts, definitions and models of expertise. For an extensive approach, see for instance Ericsson, Charness, Fetlovich and Hoffman (2006). However, to get a substantial picture of the relevance of expert theory for this study, a description of the difference between identification and development of expert performance is needed. In the following I will give an account for this difference and then turn to present a framework that can be used as an explorative approach towards assessing expert characteristics for crew operating in the maritime domain.

Description and Development of Expert Performance

A great deal of research on expertise has been inspired from the cognitive science tradition which holds that experts are skilled, competent and think qualitatively different than novices. This is also the case for the decision-making literature that searches to identify how experts reason differently from novices (See for instance Klein, 1998). As a consequence, expert theories have focused on skill acquisition with little regard for the domain or contextual factors that affect expertise development (Grenier & Kehrhahn, 2008). The literature that focus on linear stages of expertise may help researchers identify expertise, but do not necessarily help them understand how expertise develops or how it is maintained (Grenier & Kehrhahn, 2008). In an ever-changing work environment, this development is of great interest.

In dynamic environments, such as on a marine vessel, the state of the process can change irrespective of operator action. One way of studying the skills and knowledge involved in controlling a dynamic task is therefore to make experimental research and compare operators with various levels of expertise (Cellier et al., 1997). Expert – novice experiments have however received some criticism as a method since it is essential that one knows what kind of activities that occur naturally in the relevant domain (Ericsson, 2006a) In a dynamic environment, this is close to impossible to predict. An alternative approach would be to look for those characteristics experts hold across different domains. Shanteau (1992) claimed to have identified such characteristics.

Psychological Characteristics of Experts

Shanteau (1992) point out that expertise is not a fixed state to be attained, but a continuous process of learning, experimenting, and reflecting in response to changes in contextual forces. He furthermore argues that the environment in which expertise is enacted has some influence over its identification and development. This view is in line with Grenier and Kehrhah (2008), who sympathize with the literature that signify the critical relationship between domain and expertise.

Shanteau (1992) claims that his view differs from the cognitive science tradition, which holds that experts are skilled, competent, and think qualitatively different from novices. He argues that the skills and abilities that emerge (or do not emerge) depend on the situation they work in. However, based on his research, Shanteau claims that he has been able to identify 10 characteristics and seven strategies that characterize experts across different domains. These are:

> *Characteristics:* 1) Extensive and up to date knowledge, 2) highly developed perceptual/attentional abilities, 3) sense of what is relevant when making decisions, 4) ability to simplify complex problems, 5) ability to communicate, 6) handle adversity better, 7) better at identify and adapt to exceptions, 8) self confidence, 9) adapt decision strategies to changing task conditions, 10) strong sense of responsibility and willingness to stand behind their recommendations.
> *Strategies:* 1) Willingness to make continuous adjustment, 2) get help from others to make better decisions, 3) make use of formal or informal decision aids, 4) make small errors to avoid making large mistakes, 5) operate as though coming close is good enough, 6) follow some sort of divide and conquer strategy, 7) break problems down.

The observant reader may notice that Shanteau's framework also highlights some social elements of expertise, such as communication and sense of responsibility. These dimensions have gained much attention in recent years due to the acceptance that modern work requires an integration of both cognitive and social skills (Farrington-Darby & Wilson, 2006). The maritime industry has for instance increased focus on non-technical skills trough training in simulation and crew resource management (CRM), or bridge resource management (BRM) (Barnett et al., 2003; Salas, Wilson, Burke, & Wightman, 2006).

Shanteau's framework is an extensive set of factors, which also makes it a good starting point for an explorative study in the maritime domain. Expert characteristics in marine operations seem to be an absent topic in current research literature. For organizational issues, on the other hand, there exists a more familiar subject, namely safety culture and safety climate.

Organizational issues – Safety culture and safety climate

Within the maritime domain, the notion of safety culture gained more attention after implementing the International Safety Management code in 1994 (Trafford, 2009). The idea of safety culture evolves from the interest at gathering information of why certain norms and attitudes towards behavior exist (Guldenmund, 2000). Safety culture is important because it forms the context within which individual's safety attitudes develop. In spite of its obvious relevance, investigators in the maritime domain has given safety culture relatively little attention (Barnett et al., 2003), but recent studies shows an increasing interest for these issues (see for instance Håvold, 2010; Oltedal and Wadsworh, 2010).

What is Safety Climate?

According to Flin and colleagues (2000) safety climate can be regarded as "*the surface features of the safety culture discerned from the workforce's attitude and perceptions at a given point of time"* (p. 178). Safety climate is in other words a manifestation of safety culture in the behavior and expressed attitude of employees at a given point of time. It is becoming accepted that a favorable safety climate is essential for safe operation. Furthermore, the relationship between safety climate and performance is a central component in complex systems. A ship's staff, for instance, is constantly focusing on safety, not only because of the risk of injuries, but also in terms of fiscal drivers form the industry in the sense that ships often are chartered on the strength of their safety performance (Hetherington et al., 2006). Questionnaires of safety climate can therefore be used to determine the importance of safety within an organization, or identify areas that require further attention.

Safety climate is usually measured trough a questionnaire survey with the purpose of gathering scores on a series of thematic dimensions that tap into people's evaluation of various aspects considered to be relevant for safety (Guldenmund, 2007). It is often the researcher that chooses which dimensions that are relevant to measure. There has, however, been some dispute about the value of using such questionnaires when measuring safety climate. Guldenmund (2007) argues that the use of questionnaires does not successfully expose the core of an organizational safety culture, as it merely invites respondents to simply espouse rationalizations of safety climate. As a result you are stuck with a set of factors and scores and not knowing what they actually mean or imply.

Testing the Applicability of a Generic Model of Safety Climate in Demanding Maritime Operations

Flin and colleagues (2000) conducted a review where they searched through 18 published reports on safety climate used in various industrial sectors in search for a generic structure of safety climate. They concluded with a six-dimension structure, consisting of: 1) *management commitment*, 2) *safety system*, 3) *risk*, 4) *work pressure*, 5) *competence*, 6) *procedure / rules.* In addition, they brought up the dimension *blame* and *organizational learning.* A further specification of the dimensions is presented in the methods section. These eight dimensions, from now on referred to as the safety climate model (SCM), have previously been validated through qualitative interviews and found relevant for the maritime domain (Imset, 2008; Salvesen, 2008). However, although SCM is found relevant for the maritime domain, this does not necessarily entail that it can account for the same aspects connected to carrying out complex maritime offshore operations.

Assessing Safety and Efficiency Issues in Maritime offshore operations: Personnel issues vs. Organizational issues

In summary, human factors practitioners interested in understanding various elements that affect system safety and performance in complex systems, are guided by several implicit and explicit assumptions of where variability and stability in a system can be identified and furthermore which approaches that are best suited for assessing these issues. As showed in the studies of Gould et al. (2006) and Hetheringthon et al. (2006), there are several factors influencing maritime safety, being both individual oriented and organizational oriented. Equally important, these studies reveal that it is of little value to distinguish elements that are casual or contributing causes.

There is surprisingly little relevant human factors research that discusses the discriminate sensitivity of different approaches. Needless to say though, all perspectives are important. However, in an industry where time is a deficiency, it is of great value to assess knowledge that could tell something about their immediate relevance and/or their possibly overlapping features. As Woods and Dekker (2000) emphasized over ten years ago, there is an enormous need for human factors practitioners to develop techniques and models that can generate knowledge of human performance in dynamic work.

This study will therefore examine to which extent two generic models from respectively a personnel-centered approach, with a model of expertise, and an organizational centered approach, with a model of safety climate, account for the same topics that experienced marine officers bring up when asked about their work practices in demanding maritime operations.

Present Study

The main purpose of this study is to empirically test whether a model of safety climate or a model of expertise is more sensitive at capturing statements from operating marine officers regarding work practices in demanding maritime operations. Semi-structured interviews were conducted on experienced offshore marine officers to gather reflections towards their way of work during demanding maritime operations. The interviews were structured in a SWOT framework, which aims at identifying current strengths and weaknesses, and future opportunities and threats about the subject matter. SWOT interviews are open and do not guide participants in any direction. This method is therefore helpful in exploring a general topic.

Based on the discussion above, both personnel-related- and organizational-related approaches make some assumptions about what to look for when gathering relevant data in relation to how work is carried out. A generic model of expert characteristics is meant to account for high performance among individuals. Shanteau (1992) claimed that his framework should be valid across different domains. If Shanteau's framework account for the same topics that the crew find significant in relation to their way of work, then this model should account for the majority of statements generated from the interviews. The following hypothesis will test this notion:

Hypothesis 1) There will be no significant differences between number of identified statements in total and the number of statements accounted for in the model of expert characteristics by Shanteau (1992).

On the other side, an organizational-centered approach such as safety climate should be sensitive at capturing the manifestation of safety culture in the behavior and expressed attitude of employees. SCM by Flin (2000) have earlier been validated trough SWOT interviews and found relevant for the maritime domain (Imset, 2008; Salvesen, 2008). If SCM is a sensitive measure for how officers perceives and reflects about their work in demanding maritime operations, then SCM is expected to account for all statements regarding work practice in demanding maritime operations. Hypothesis 2 will test this notion:

Hypothesis 2) There will be no significant differences between number of identified statements in total and the number of statements accounted for by safety climate model by Flin et al. (2000).

As discussed above, work in complex system involves many cross-scale interactions between the different components in a sociotechnical system (Rasmussen, 1997). It may therefore be that a cross-disciplinary organizational-centered approach combined with a personnel-centered approach would give the best picture of how officers reflect upon their way of work. The following hypothesis will test this notion:

Hypothesis 3: There will be no significant differences between number of identified statements in total and number of statements accounted for by both model of expert characteristics and safety climate model together

Following the rationale behind hypothesis 1, 2 and 3, it is expected that statements not accounted for by either PCE or SCM will be redundant information. The following hypothesis will test this notion.

Hypothesis 4: Residual statements not accounted for by either a model of expertise and safety climate is not relevant for how work is carried out in demanding maritime operations.

Method

The Research Project

This study was a part of a long-term project between the department of work and organizational psychology at the University of Oslo (UiO) and maritime studies at Vestfold University College. These departments are currently involved, together with Kongsberg Maritime, and Chalmers University, in an innovation project called SIMAR (simulation of demanding maritime operations). The project is founded by the research Council of Norway from 2010 until 2013, with the aim of improve simulation training by enhancing focus on human factors.

Recruiting Participants

Offshore support vessels are considered demanding to operate (NOU, 2008: 8) Hence, the targeted group for this study was officers working at offshore vessels, primarily officers at anchor handling tug support vessels (AHTS), and officers at platform supply vessels (PSV). These vessels are for the most time at sea, and have unpredictable scheduling for when and where they are expected to be ashore. Recruiting participants was therefore depended upon close cooperation with offshore shipping companies in addition to maritime training facilities.

Shipping Companies. Six of the largest offshore shipping companies in Norway were contacted. A written information letter followed up every request by e-mail. Two shipping companies had available resources to follow up the request. With regard to confidentiality, the names of the companies are not cited. One shipping company sent us contact information to the near by vessels who expected to go ashore in the nearest future. It was important that the captain agreed upon this arrangement. The captains of these vessels were contacted and received the general information letter (Appendix A) in addition to the information letter for participants (Appendix B). The captain was asked to inform the officers onboard about the project. Participation was voluntary. Although several vessels were willing to assist the project, only two vessels at various locations along the coast of Norway were visited. Tight schedules and long travel distances made it difficult to arrange meetings. In sum, six participants were interviewed this way.

The second shipping company contacted their officers through their internal channels. One captain showed interest in participating and responded to the request, and a meeting was arranged.

Training facility. One training facility was contacted and asked to forward the request to AHTS officers participating in a training program. Three captains had available time and agreed to participate. A meeting was soon after arranged at the training facility.

Sample. In sum, ten officers were recruited. Six of these were master chiefs (captains), two had the rank chief officers, and two participants had the rank second officer. Seven of the officers were working on AHTS-vessels, and three (one of each rank) from PSV-vessels. Between them they had over 200 years of shipping experience, ranging from eight to 45 years (SD = 8.8). All participants were male. Mean age was 40 years (SD = 8.9). One participant had national origin from Brazil; the remaining nine was Norwegian.

The Interviews

The purpose of conducting interviews was to obtain officers reflection upon work practices in demanding maritime operations. Hence, in order to maximize the amount of information gathered from participants, semi-structured interviews were seen as the most appropriate method. The interviews were based on a SWOT-frame (Helms & Nixon, 2010; Hoff, 2009). SWOT is an acronym *for strengths, weaknesses, opportunities, and threats*, and is well-known framework from its popularity as a strategy tool for organizational development, but can also be applied to individuals (Helms & Nixon, 2010). SWOT-interviews are helpful in exploring a general topic, and are a suited framework to guide an interview (Hoff, 2009).

The objective of the SWOT-interviews was to give officers the opportunity to freely reflect and explain what they saw as strengths and weaknesses in their current work practice in demanding maritime operations, and further what could be future possibilities and threats towards the way they worked in demanding operations. Since the topic "demanding maritime operations" can be widely understood, the first interview-question asked them to explain what they think demanding maritime operations is all about, pinpointing the theme for the rest of the interview. In addition to the five main interview questions, some follow up questions such as: *"you said…can you please elaborate?"* was used to gain more insight and better understanding of the themes brought up (Kvale, 1996).

Procedure

Preparations: As in all qualitative research, is critical to acknowledge that the researcher is the primary research tool. Preparation and training is therefore critical to ensure validity and reliability in all stages of the process, from the interview (Kvale, 1996) to transcribing and analysis (Braun & Clarke, 2006; Krippendorff, 2004). The author, who conducted all interviews, had participated in a 35-hour preparatory interview course with professor Roald Bjørklund (UiO) based on the PEACE-model (Clarke & Milne, 2001). The course was specifically aimed at training for SWOT-interviews. In addition, the author had experience as a research assistant in similar studies and was well trained for the interview situation.

Carrying out the interviews: The interviews were conducted in the period from October to December 2010. Six of the interviews were conducted on the vessels where the participant normally worked. The remaining four were conducted in a meeting room wherever the participant was available. All interviews where conducted in a silent environment, avoiding noise or disturbances that could interrupt the participant.

The approach for the interview was based on the PEACE model (Clarke & Milne, 2001). The participants were informed about the purpose of the study and how the data would be used. All participants were assured confidentiality and the right to withdraw from the study at any time. All participants signed a written consent and agreed upon being tape-recorded.

Lengths of the interviews: The lengths of the interviews varied between 30 and 70 minutes and had in average a duration of 45 minutes (SD=17,23).

Processing The Interviews and Analysis

Transcribing: The interviews were recorded on a digital recording device and later copied to a computer. The interviews were then transcribed verbatim. Words that had no semantic significance, such as repetitions and hesitation, were excluded. The author transcribed five of the interviews. The remaining five was shared between two fellow students. Four of the interviews were crosschecked by listening trough the taped interview and note significant discrepancies between the tape and the transcript The proofreading showed an all over good quality of the transcribed interviews.

Unitizing: In order to code and analyze a recorded stream of verbalization, in this case the interviews, it is necessary to segment the text into smaller units. Unitizing means identifying units of coding within a text (Krippendorff, 2004). The goal of unitizing is to select the empirically most meaningful and informative units that are both reliably identifiable and relevant for the following analysis. To achieve these often conflicting objectives, one has to make compromises (Krippendorff, 2004).

One of the purposes of identifying statements was to make it possible to see which statements that could later on be categorized onto existing theories or models. This is called a modeldriven SWOT approach, or M-SWOT (Hoff, 2009). M-SWOT analysis have earlier successfully applied principles from content analysis and have defined a statement as *"the smallest meaningful unit that reflects the informant's experience and understanding of the topic of interest"* (Hoff, Flakke, et al., 2009, p. 7). Such statement can involve a part of a sentence, a whole sentence or several sentences, according to this definition.

What defines meaningful will ultimately rely on the researcher's judgment. M-SWOT analysis usually guides identification of statements from the categories given in the analysis (SWOT/ theoretical model). As the present study is foremost an explorative study it was a primary concern *not* to disregard statements that did not account for any pre-known categories or theories. Hence, in addition to the definition mentioned above (Hoff, Flakke, et al., 2009), a user-defined, declarative unitizing instruction was applied.

The important thing was that a statement is understood as the participant's reflection to the interviewers question and topic of interest (demanding maritime operations, and the way they worked), independent of any models and theories about the topic. A statement should be, to the extent possible, comprehensible by itself and contain only one piece of information, idea, evaluation or point of view. It is considered a new statement if the participant expresses a new piece of information, semantically different from the previous. The complementary unitizing instruction can be found in Appendix C.

Coding: Statements from the transcribed interviews were then transferred into PASW statistics for coding. By following the principles from M-SWOT analysis, each statement was tested to see if they could fit into existing categories of the chosen models. Each statement were coded in three models; SWOT, the model of psychological characteristics of experts (PCE), developed by Shanteau (1992), and SCM, adapted from Flin et al. (2000). Statements were first of all coded in the SWOT model that included four categories, inspired from Chermack and Kasshanna (2007):

Strengths: Positive aspects of the way they work and handle demanding maritime operations or daily work today. Can be competencies, capabilities or strengths with a certain practice. Dimension: Here and now.

Weaknesses: Negative aspects of the way they work today and handle demanding maritime operations or daily work. Can be lack of competencies, skills, capabilities or weaknesses with a certain practice. Dimension: Here and now.

Opportunities: Positive aspects of how things could be done better in the future for how they work. How they could improve, or handle demanding operations better in

some way. Something they don't have today. Dimension: Future.
Threats: How the way they work today could evolve in a negative way. Negative circumstances which could make things even worse, or set safety and efficiency at stake. How could things get even worse than it is today? Dimension: Future.
SWOT residual: Statements that do not fit into any of the above SWOT category. E.g. normative utterances such as "there is much work to do these days".

Shanteau's (1992) model of psychological characteristics of experts (PCE) explain general characteristics that experts tend to show. To see if these characteristics fit any of the statements reflected by the participants the principles of M-SWOT analysis were applied (Hoff, Flakke, et al., 2009).

Although the title of each category in Shanteau's theory is comprehensible, the given description of each category is normative and relatively short; hence in order to achieve sufficient reliability in the coding process, a small elaboration of each category was needed. Each category was considered value-free in the coding process. The characteristic 9) "adapt decision strategies to changing task conditions", and strategies, 5) "operate as though coming close enough", 6) "follow some sort of divide and conquer strategy", and 7) "break problems down" where excluded from the analysis due to a great deal of overlapping with other categories. This will be further discussed in the limitation part. As a result, five of the categories were excluded. The categories were defined as follow:

1. **Content knowledge:** deals with knowledge and experience expressed to be important, e.g. details about what you get from experience and knowledge needed in order to work safe and efficient.
2. **Perceptual/attention abilities:** deals with the characteristic of having the "correct" attention and concentrate on important things.
3. **Sense of what is relevant when making decisions:** deals with distinguishing relevant from irrelevant materials when working, e.g. don't waste time on insignificant things.
4. **Simplify complex problems / break problems into simpler parts:** deals with making sense out of chaos or to adapt decision strategies to changing task conditions, e.g. break problems into parts and handle it from there.

5. **Communication:** deals with communication and the importance of this aspect of their work, e.g. the importance for them to communicate a collective understanding of the task.
6. **Handle adversity:** deals with the ability to work under stressful conditions and to keep calm and steady.
7. **Identifying and adapting to exceptions / make continuous adjustment:** deals with adapting to special situations and to work outside the box. Novices, for instance, persist on following well-established rules.
8. **Self-confidence in decision-making:** Covers statements that express something about self-confidence and faith in ones abilities. Experts tend to believe in themselves and their capacity to make good decisions.
9. **Strong sense of responsibility:** Covers statements that express something about responsibilities and how responsibility affect their work-practice.
10. **Get help from others to make better decisions:** deals with their work practice involving seeking feedback from others, and consolidation with colleagues and subordinates to gain insight. Also covers group interaction.
11. **Make use of formal or informal decision aids:** deals with the usage of aids that are needed to assist their work in decision-making. For instance, written records of prior decisions or standard rules or procedures that help them doing their work.
12. **Try to avoid making large mistakes:** deals with statements that express their priority to avoid making large mistakes that could include that coming close is good enough.
13. **Residual:** statements that do not fit to any of the above categories.

The safety climate model (SCM) is based on a review article by Flin et al. (2000) where they identified a set of common dimensions of safety climate based on 18 published reports of safety climate surveys. The definition of the dimensions is based on Flin et al. (2000), and Imseth (2008).

1. **Management:** Perceptions of management's commitment, attitudes or behavior in relation to safety, production or other issues (selection, planning, satisfaction with supervisor etc.)

2. **Safety system**: perceptions of the organization's safety management system such as state of performance of safety officials and committees, safety policies, safety equipment, etc.
3. **Risk perception:** Self reported risk taking, perceptions of risks, hazards, or attitudes towards risk and safety.
4. **Work pressure:** Challenges regarding pressure for production and safety
5. **Competence:** Qualifications, skills and knowledge. Level of qualifications. Selection, training, standards.
6. **Procedures/rules:** Perceptions of safety rules, attitudes to rules and compliance or violations of procedures.
7. **Blame**: Perceptions of how blame is distributed in the wake of accidents or incidents
8. **Organizational learning.** How the organization learns from experience.

Inter-rater Reliability in Coding Statements

Since familiarity with the text and its theme is a prerequisite for reliable coding, the coding was done after transcriptions and unitizing (Krippendorff, 2004). Furthermore, to ensure consistency in the coding process, a randomly selected interview was early in the coding process tested for inter-rater reliability using Cohen's Kappa. Cohen's Kappa was considered the best measure for inter-rater reliability since this measure account for the probability of agreement by chance. Both the author and a fellow student coded a part of a randomly selected interview by following the coding instructions. The results showed a Chohen's Kappa (κ) of .671 on the SWOT categories, .503 on SCM, and .432 on PCE. According the benchmark standards for interpreting Kappa by Landis and Koch (1977), the level of agreement is considered substantial on the SWOT categories, and a moderate on SCM and PCE.

Content Analysis

Statements not accounted for by either of the models were qualitatively analyzed. Two approaches for this process were considered; thematic analysis (Braun & Clarke, 2006), and content analysis (Krippendorff, 2004). The two techniques share many similarities, but content analysis pays greater attention to the quantitative aspects of the analyzed material. Since the identified themes and patterns in the text will be counted and represented in a hierarchal order, content analysis was considered most appropriate tool.

Statistical Analysis

After coding statements in PASW statistics, it was possible to run statistic analysis to test whether there were systematic differences in the dataset. Paired t-test was conducted in able to test the stated hypothesis.

Ethical Considerations

Voluntary participation. All participations were voluntary, and each participant was well informed about the project trough briefing from the interviewer and the information letter given on beforehand. Each participant signed an informed consent were they were informed about their possibility to withdraw from the study at any time.
Some of the participants were recruited trough their supervisor, and could possibly feel some obligation to participate although participation was completely voluntary.

Confidentiality. The participants were assured confidentiality of any information gathered from them. Both personal names and the name of the respective shipping company each participant belonged to will not be cited.

Tape recorder. Each participant verbally agreed upon being tape-recorded. The use of a tape recorder was also stated in the informed consent. The participants were informed about how the tape-recorded interview would be transcribed, but ensured that no information could be traced back to them. The use of tape recorders can be inconvenient for the participant since this can make the situation more formal and serious. This was rendered harmless trough briefing of the purpose of using this equipment.

Treatment of data. The tape-recorded interviews were transcribed and then later deleted. The transcribed interviews will remain in the department, but will not be used outside the terms cited in the written consent (Appendix B)

Health consequences. The interview was not regarded to have any negative impact on health, and the participants were treated in accordance to principles in PEACE (Clarke & Milne, 2001) and the Norwegian Work Environment Act , emphasizing integrity and respect.

Results

Descriptive Results

It was identified a total of 1947 statements (*M* = 194.70, *SD* = 93.17) regarding demanding maritime operations, and the way working in demanding maritime operations from the ten interviews. All statements were first coded in SWOT, and then coded on the model of psychological characteristics of experts (PCM) and Safety Climate Model (SCM). *SWOT:* In sum, 1053 (54,1 %) of the total number of statements could be accounted for in SWOT. The distribution of statements on the SWOT categories is presented in Table 2.

Table 2: *Distribution of statements in SWOT (N=10)*

	Frequency	Percent	Mean	Std
Strengths	617	31.7 %	61.7	28.69
Weaknesses	179	9.2 %	17.9	20.78
Opportunities	71	3.6 %	7.1	8.3
Threats	186	9.6 %	18.6	14.42
Sum SWOT	1053	54.1 %	105.3	53.41
Residual	894	45.6 %	89.4	49.28
TOTAL	1947	100 %	194.7	93.17

As shown in Table 1, the distribution of statements in the SWOT-categories is not evenly distributed. The majority of the statements were accounted as strengths, with 617 (31.7 %) statements. Next, threats with 186 (9.6 %), then weaknesses with 179 (9.2 %) statements, and finally opportunities with a total of 71 (3.6 %) statements. The remaining 894 (45,6 %) of the total 1942 statements could not be counted for as SWOT statements. Statements not accounted for by SWOT were value-free statements that were considered relevant for the research question and were not excluded from the following analysis (e.g. *"there are always clients onboard when we carry out a job"*, "*there are never two similar days"*, *"it is much about experience and what you have practiced earlier").*

Psychological characteristics of experts (PCE): In sum, 771 (*M* = 77.1*, SD*= 34,03) of the total 1947 identified statements could be accounted for in the model of psychological characteristics of expertise. *Content knowledge* had the highest number of statements with 236 (12.1 %) statements. The second highest number of statements was identified in the category *"Make use of formal or informal decision aids"* with a total of 111 (5.7 %) statements. The distribution of statements in PCE is presented in Table 3.

Table 3: *Distribution of statements in psychological characteristics of expertise (N=10)*

Psychological Characteristics of expert	Sum	%	Mean	SD
1. Content knowledge	236	12.1 %	23,6	18.63
2. Perceptional and attention abilities	38	2.0 %	3.6	2.85
3. Sense of what is relevant when making decisions	31	1.6 %	3.1	2.92
4. Simplify complex problems	11	0.6 %	1.1	1.37
5. Communication	79	4.1 %	7.9	9.36
6. Handle adversity	53	2.7 %	5.3	3.94
7. Self confidence in decision making	59	3.0 %	5.9	6.72
8. Adapt decision strategies to changing task conditions	44	2.3 %	4.4	2.79
9. Strong sense of responsibility	25	1.3 %	2.5	2.41
10. Get help from other to make better decisions	77	4.0 %	7.7	3.40
11. Make use of formal or informal decision aids	111	5.7 %	11.1	8.30
12. Avoid making large mistakes	7	0.4 %	0.7	1.56
SUM PCE	771	39.6 %	77.1	34.03
13. Residual	1176	60.4 %	117.6	66.44
TOTAL	1947	100 %	194.7	93.17

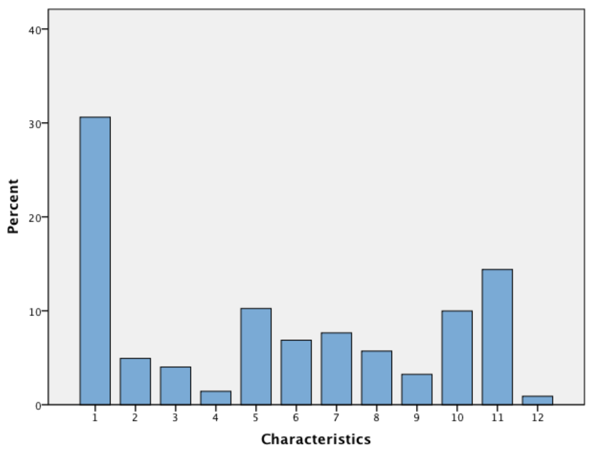
As shown in Table 3, the standard deviation on the category *content knowledge* is relatively high, indicating that some participants contributed with more statements than others.

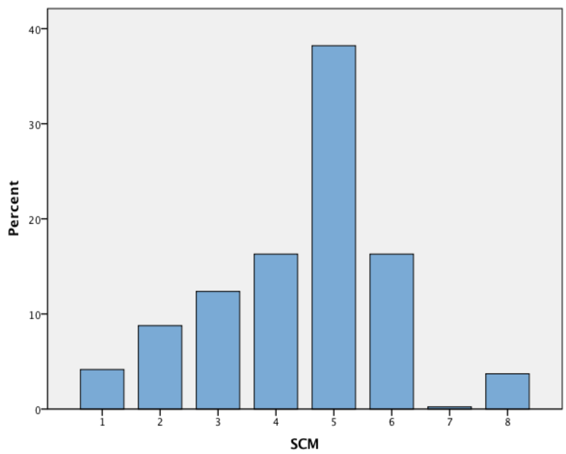
SCM: Safety climate model accounted for 890 (*M*=89, *SD*=45.68) statements of the total 1947 identified statements from the interviews. The distribution is presented in Table 4. The highest number of statements were identified in the category *"competence, training"* with a total of 340 (17.5 %) statements. Next, the categories *work pressure* and *procedures/rules* both got 145 (4.5 %) statements each. The category *blame* was identified two times (0.1 %), and had the lowest number of statements in SCM.

Table 4: *Distribution of statements over SCM (N=10)*

SCM	Sum	%	Mean	SD
1. Management	37	1.9 %	3.7	4.92
2. Safety systems	78	4.0 %	7.8	6.05
3. Risk perception	110	5.6 %	11	10.64
4. Work pressure	145	7.4 %	14.5	13.50
5. Competence, training	340	17.5 %	34	23.65
6. Procedures / rules	145	7.4 %	14.5	12.67
7. Blame	2	0.1 %	.2	0.63
8. Organizational learning	33	1.7 %	3.3	2.79
SUM SCM	890	45.7 %	89	45.68
9. Residual	1057	54.3 %	105.7	52.99
TOTAL	1947	100 %	194.7	93.17

Figure 1 & 2*: Graphical representation of percentage distribution of statements on PCE and SCM. PCE is presented on the left, and SCM on the right.*

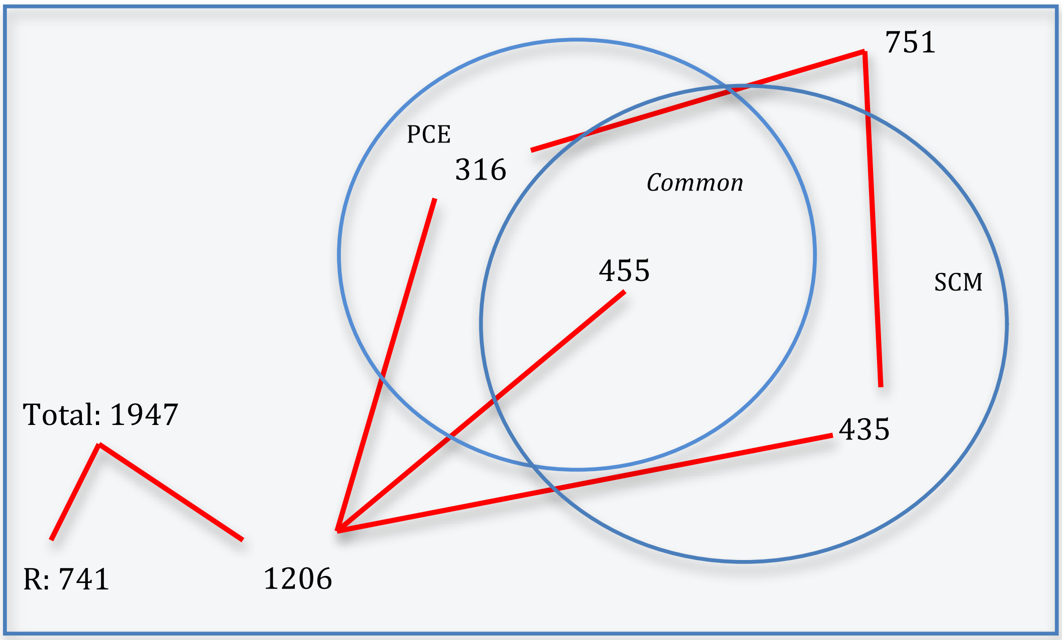




As shown in Figure 1 and 2, all categories were activated from the interviews, but display uneven distribution.

PCE and SCM together. Figure 3 illustrates the relative coverage of statements between PCE and SCM. In sum, 1206 statements could be accounted for in SCM and PCE. This constitutes 61.9 % of the total 1947 statements. In sum 455 (23.4 %) of the statements could be coded in both PCE and SCM. The unique coverage of PCE and SCM then becomes 316 and 435 respectively.

Figure 3: *Illustrating relative distribution of statements on models.*



Note: PCE= Psychological characteristics of experts, SCM= Safety Climate Model, R=residual statement

A closer examination of the overlapping statements shows that the majority of these includes statements that is identified as 5) *competence / training* in SCM, which is distributed amongst several characteristics on PCE. Table 5 displays crosstab of statements between PCE and SCM that shows which categories that covers the same statements. Also worth noticing from Table 5 is that be the category 11) *make use of decision aids* in PCE have some overlapping features with all categories in SCM, except category 7) *blame.*

Table 5: *Crosstab safety climate model (SCM), and psychological characteristics of experts (PCE)*

	SCM									
PCE	1	2	3	4	5	6	7	8	9 (R)	SUM
1	4	3	10	8	106	14	0	4	87	236
2	0	0	4	0	18	0	0	0	16	38
3	0	0	4	0	17	0	0	0	10	31
4	0	0	0	0	4	0	0	0	7	11
5	0	0	0	3	34	5	0	0	37	79
6	1	0	3	3	18	0	0	2	26	53
7	0	3	6	3	10	6	0	0	31	59
8	0	0	6	6	8	0	0	0	24	44
9	0	1	7	1	2	0	0	0	12	25
10	2	3	1	0	5	15	1	11	40	77
11	3	35	5	1	5	39	0	4	19	111
12	0	0	1	0	0	0	0	0	6	7
13 (R)	27	33	63	120	113	66	0	12	741	1176
SUM	37	78	110	145	340	145	1	33	1057	1947

Note: SCM: 1= Management, 2=Safety system, 3=risk perception, 4=Work pressure, 5= Competence, 6=procedures, 7=Blame, 8= Organizational learning, 9=residual

PCE: 1= Content knowledge, 2=perception, 3=sense of what is relevant when making decisions, 4= Simplify complex problems, 5= competence, 6= Handle adversity, 7= adapting to exceptions, 8=Self confidence, 9= strong sense of responsibility, 10=get help from others to make better decisions, 11=make use of decision aids, 12=try to avoid making large mistakes, 13=residual.

Test of Hypothesis

Hypothesis 1 predicted that there would be no significant differences between number of identified statements in total and the number of statements accounted for in the model of expert characteristics by Shanteau. In order to test this hypothesis, a paired t-test was carried out to compare the total amount of identified statements (M = 194.70, SD = 93.17), and statements accounted for in PCE (M = 77.1, SD = 34,03). The results revealed a significant difference between the two groups, $t(9)$ = 5.597, p <.000.

Hypothesis 2 predicted that there would be no significant differences between the number of statements accounted for in total and the number of statements accounted for by SCM. A paired t-test was carried out to compare the total amount of identified statements ($M = 194.70$, $SD = 93.17$), and statements accounted for in SCM ($M = 89$, $SD = 45.68$). The results revealed a significant difference between the two groups $t(9) = 6.308$, $p < .001$.

Hypothesis 3 expected that there would be no significant differences between number of identified statements in total and the number of statements accounted for by both model of expert characteristics and safety climate model combined. To test this hypothesis, a paired t-test examined the difference between the total amount of statements ($M = 194.70$, $SD = 93.17$) against the combined number of hits on PCE and SCM ($M = 120.6$, $SD = 56.6$). The results revealed that there was a significant difference between the two groups $t(9) = 5.686$, $p < .001$.

Hypothesis 4 expected that statements not accounted for after coding in both PCE and SCM would be redundant information and have no relevance to how work is carried out in demanding maritime operations. To closer examine this assumption, the residual statements were analyzed by conducting a content analysis with the aim at identifying themes and patterns in the text. The analysis resulted in 24 identified themes, which were then placed into one of three categories; individual, group, and work domain, for a pragmatic differentiation of the themes. A summary of the analysis is presented in Table 7.

Table 6: *Content analysis of the residual statements.*

Context	Theme	Number of statements
Individual	Planning and project management	45
	Trial and error, errors caused by habits etc.	31
	Tough work	23
	Boat handling / ship sense	25
	Multitasking	21
	Lack of rest	13
	Interest and engagement in work	12
	Stress / illness	10
	Administrative work / paperwork	9
	Creativity	8
Group	Teamwork	71
	Teach/training of new staff	25
	Cultural differences in workforce	22
	Ageing workforce	9
Work domain	Technical and mechanical equipment	51
	Advanced technology and better vessels	37
	Weather conditions/ environmental constraints	35
	Hands on experience from working on deck	32
	Clients	30
	Differences between vessels	28
	Economy and organizational development	28
	Suppliers of equipment	17
	Differences in each operation	13
	International workforce	9
	Not relevant	137
Sum		741

As presented in Table 6, themes placed at the individual level deals with matters that are relevant from a personal point of view. Planning and project management, for instance, were mentioned quite often, referring to the importance of having a clear plan of how the operation should be carried out. Lack of planning could be a possible threat to safety. Trial and error were also mentioned relatively often, referring to the fact that failures, both human and technically, is a normal thing. Also a part of daily work is the fact that tasks are sometimes physically hard, and that certain guts are required to handle daily challenges. Many participants also mention the importance of manual boat handling, and that freshmen often lack this skill. Stress and lack of rest can in turn have a negative effect on safety and efficiency. Stress and lack of rest were sometimes related to a few statements that focused on the negative impact of constantly more paperwork when performing their duties. Finally, creativity was also highlighted as an important characteristic with how to deal with unanticipated working conditions.

On group level, there were mainly four important aspect not accounted for in the models used in this study. Teamwork accounted for a majority of these statements, including both positive and negative aspects of teamwork in their daily work. Several participants also mentioned the importance of paying attention to training of new staff and that experienced officers should be more willingly to spend more time on training inexperienced workers. Next, cultural differences between the crew were mentioned as an important aspect related to communication and collective understanding of a critical operation. Finally, some participants mentioned an ageing workforce as a general concern in the future.

Themes placed in work-domain level deals with statements reflecting constraints in the work-environment relevant for how they perform their work. Technical and mechanical equipment, for instance, are mentioned quite often. This theme emphasizes the importance of having a conscious awareness of the equipment they use. Another aspect of their work was related to the continuous and rapid technological development in for instance the instruments they use. The increasing detail-level at the surveillance monitors was for instance a rather negative feature that could increase complexity of their work. Another constraint frequently mentioned was the weather conditions and the need to assess this aspect of the operation constantly. Understanding wind and underwater current that affect boat performance are critical for safe performance.

Statements regarding clients onboard were also mentioned several times. Sometimes this aspect was positive, having someone to discuss safety-issues with. In other circumstances, having clients onboard was perceived as an additional stress-element when performing complex tasks. Another theme dealing with work-domain issues were about lack of involvement from equipment-suppliers. Some participants mentioned the importance of customizing equipment design in accordance with the requirements from the users. Lastly, some participants mentioned that all work involves a great deal of situation-depended situations, and that each operation has its unique features, making it difficult to relate their work to a specific situation.

Summing up, a clear majority of the residual statements involve information that is relevant for how they work in demanding maritime operations. The 137 statements marked as *not relevant* did not contain any semantically meaningful information related to how they work. A great deal of these statements included small talk, and citations expressing lack of reflection of the issues that were discussed; “I haven’t thought about these matters so much”.

Discussion

Summary of Results

The purpose of this study was to empirically test two different models/framework that account for human factors and test their ability to account for reflections of work practice in demanding maritime operations, gathered from semi-structured interviews. Analysis shows that the semi-structured interviews generated a lot of information regarding AHTS- and PSV officer's way of work. A total of 1947 statements were identified and coded in PCE and SCM. The descriptive results show that, individually, PCE accounted for 39.6 %, while SCM accounted for 45.7 % of the 1947 statements. When these models are applied to the same dataset simultaneously, they could account for 61.9 %, or 1206 statements. In other words, the combined models could account for a larger part of the statements than they could individually. However, as illustrated in Figure 3, a majority (455) of these statements could be coded in both PCE and SCM. This implies that they are to some degree accounts for the same aspects that were brought up in the interviews.

Hypothesis 1 was applied to test whether a model of expertise, based on Shanteau (1992) was able to account for the same topics that marine officers brought up when asked about their work practices in demanding maritime operations. Despite that the model was considered an extensive framework, the analysis show that only 771 of the 1947 statements from the interviews could be accounted for by PCE. The distribution of statements as presented in Table 3 shows that all categories were activated, and the category *content knowledge* was identified in over 12 % of the cases. The t-test test shows that there were statisticaly significant differences between the group of identified statemements in PCE and in total. This implies that the number of matching statements was too small to say that the model can account for the majority of data that was gathered in this study. For this reason, hypothesis 1 could not be supported

Hypothesis 2 was applied in order to test whether a safety climate model, based on a generic framework presented by Flin et al. (2000) could account for the same topics that marine officers brought up when asked about their work practice in demanding maritime operations. The analysis show that in sum 890 of the 1947 identified statements could be coded into the dimensions given by SCM. SCM was in other words able to account for more statements than the used model of expertise. As can be seen in the descriptive results, all categories in this model where also activated. The category "competence/ training" scored substantial more than the other categories with 17.5 % of the total amount of identified statements. Despite a higher number of identified statements than PCE, the result from the statistical analysis imply that there were substantial differences between the number of statements identified in SCM, and the number of statements identified in total. For this reason, hypothesis 2 could not be supported.

Hypothesis 3. As discussed in the introduction, studying work in complex sociotechnical system is a matter of cross-scale interactions. Woods and Hollnagel (2006), and Rasmussen (1997) argued that the large problem space and dynamic complexity of a sociotechnical system require a wide approach. The study of Gould et al. (2006) and Hetherington et al. (2006) showed that marine accidents always were a matter of multiple factors. Hypothesis 3 was therefore applied to test whether a combined model of PCE and SCM could together account for all statements generated from the interviews. The results showed that the combined models accounted for 1206, or 61.9 % of the total number of statements. This implies that they could to some degree account for a larger part of the statements than the models were able to individually. However, as shown in Table 5, a substantial part of these statements were identified in both models. Thus, the statistic analysis shows that despite its relative bigger coverage, the number of identified statements in both models was found to be significant smaller than the number of identified statements in total. Hypothesis 3 could therefore not be supported.

Hypothesis 4. Following the rationale behind hypothesis 1, 2, and 3, hypothesis 4 expected that statements not accounted for by either PCE or SCM would not be relevant for how work is carried out in demanding maritime operations. A content analysis with a following thematic categorization was conducted to test this notion. The analysis resulted in 24 main themes, as presented in Table 5, which were all considered relevant aspects towards the way they work in demanding operations. A pragmatic differentiation between themes at the level of individual, group and work domain illustrates the diversity of the themes. Beside teamwork, as the theme brought up most frequently, aspects around technical equipment and advanced technology were something that was given much attention. The importance of planning and project management was also something they often brought up as significant in relation to how they worked. The 137 identified as not relevant were mostly small talk and was short-numbered. In summary, the result from this analysis could not support hypothesis 4.

General Discussion

The maritime industry faces several challenges related to increased complexity in offshore oil- and gas production. The Bourbon Dolphin accident is an apparent example of the imminent danger demanding maritime operations involves. Rapid technological development of onboard equipment as well as changes in the organizational structure furthermore represents a shift in the way mariners cope with the demands that is presented to them. The more we understand this complexity and how the crew manage and interacts with the factors that shape behavior, the more we will be able to make the right interventions to ensure safe and reliable operations in the future. For this reason it is critical to reflect on the basic assumptions on what factors that shape human performance in complex systems.

This study shows that by using a method that avoids leading the participant in any specific direction, officers reflect about theoretically different relevant themes. The aim of using a model of expertise and a model of safety climate was not an attempt to measure the level of expertise or an attempt to measure safety climate. Instead, the models were used as frameworks to test if the topics covered in the interviews were the same aspects as those covered in the respective models. Although the results from the analysis show that the models could not account for the majority of the statements in this study, this is not the same as to say they are not relevant at all. The fact that the models combined were able to account for 61.9 % of the statements does indicate that they are to some extent relevant for assessing work in the maritime domain.

The results bring us back to the discussion about what to look for when assessing safety and performance in complex sociotechnical systems. Rasmussen (1997) argues that the cross-scale interactions between different elements in a complex sociotechnical system are fundamental aspects of how these systems work. Consequently, the aspects that shape behavior are numerous and practitioners are left with the challenge of using a relevant unit of analysis. The studies from Gould et al. (2006) and Hetherington et al. (2006) illustrate that the units of analysis can be various in a maritime context, and furthermore that organizational, personnel, and design issues makes some assumptions about where we could start looking.

The results from this study indicate that the factors the crew find significant in relation to how they perform their work are related to issues at the technical, personnel and organizational levels. In other words, it is not sufficient to look at only one of these approaches to gain a substantial picture of the factors that affect safety and performance. A model of expertise, or any other individual-centered approach for that matter, will be able to account for only some aspect that is important when performing work. Similarly, a safety climate model will account for some other relevant features, but will miss several others. Combining them is an alternative, but yet there are some aspects left out. This problem touches upon a fundamental question in how we understand and study work in complex system. Treating organizational and personnel issues as separate units of analysis will eventually leave us with some black spots that will not be accounted for.

So, where does this leave us with regard to the models used in this study? Shanteau (1992) claimed to have successfully identified a set of characteristics and strategies that is common for expert performance across different domains. The fact that statements from operating officers could be placed on all of the 12 categories used in this study show that his framework could be a useful instrument when accounting for work in demanding maritime operations. On the other hand, it is interesting to ask why over 60 % of the statements fell outside the dimensions in PCE. This might have several explanations. One might be that the model as a theoretical framework works perfectly fine, but that the participants in this study were not experts. Conversely it can be argued that the participants can be considered experts in what they do, but that the model is not capable to sufficiently account for all the dimensions that that is important for expert performance in demanding maritime operations. Based on the last argument, it is timely to ask whether the model would benefit from an update if used in a maritime context.

The answer behind the missing 60 % can perhaps best be understood in light of the results after coding statements in SCM. The descriptive results in table 3 and 4 show that the categories which received most statements in both models were about knowledge and competence / training. Håvold (2010) and Morel, Amalberti and Chauvin (2008) do also highlight that knowledge and general know-how are critical components for handling marine vessels. Furthermore, the categories *work pressure, procedure / rules, risk perception,* and *safety systems* in SCM also received a substantial amount of statements. Although this study cannot give an account for the degree of importance of these dimensions, it is reasonable to ask whether these dimensions also could be relevant when examining characteristics of expert performance in demanding operations.

Perrow (1999) argues that the structure of the maritime industry, with its social organization onboard, economic pressure, and challenges related to international regulations makes it difficult to control errors. Expert performance in a maritime context must consequently be seen in light of the various aspects that affect the overall performance of the vessel. From this perspective it might beneficial to include some of the dimensions from safety climate into the framework of expertise in a maritime context. On the other side it might be just as relevant to ask whether it is helpful to include aspects of expert performance when accounting for safety climate. The potential consequences of using a "wrong" model, either looking to study safety climate or expertise, would be that they will fail to account for critical aspects that might influence safety and efficiency in future operations.

Implications

First, the most apparent implication of this study constitute as a contribution to the research area that aims at studying the human element in complex sociotechnical systems, or more precisely towards work in the maritime domain. The results of this study show that the crew, as an integrated as a part of a dynamic environment, reflects about several constraints in their work environment, being about both individual oriented perspectives, organizational oriented and also technical oriented. The frameworks used in this study consequently failed to account for this complexity. Rasmussen (1997), Vicente (1999), and Woods and Hollnagel (2006) argue that the cross scale interactions between different parts of a sociotechnical system are a crucial aspect of how these systems works. This does also call for a cross-disciplinary research community that focuses on performance on a system level.

Secondly, a more practical implication of this study can be seen in light of the results of the content analysis of the residual statements. A clear tendency of these themes, as listed in Table 5, is that most of them are non-technical issues. Barnett et al. (NOU, 2008: 8) pointed out that although non-technical skills are acknowledged as core concepts for managing crisis at vessels, it is also recognized that these skills are context specific. This can be seen in light of the Bourbon Dolphin accident report (McGeorge, Hands, & Rugg, 1994), which argued that there was a lack of tailored guidelines for anchor-handling operations. The report furthermore stated that the expertise that is required for operating demanding maritime operations reaches far beyond the standard minimum requirements. The result from the analysis in this study show that, besides teamwork, many statements deal with the aspect of planning and managing projects, handling onboard clients and economical interest. These findings may be of interest for those designing simulation training and putting together CRM / BRM training for operating crew.

Third, future complex maritime operations require that mariners continually train to upgrade their knowledge and skills. It is thus critical that we reflect on the assumptions that underlie performance. The success of training programs always depends on the identification of appropriate interventions and requires systematically collecting, reviewing, and analyzing performance related data (Kvale, 1996). Today, human factors researchers can turn to a sizable stock of concepts that are used to express insight about human performance. Mental states such as stress, workload or situational awareness, as mentioned by Hetherington et al.

(2006) have however received criticism for being what Dekker and Hollnagel (2004) term "folk models". Folk models, they claim, focus on the state of a cognitive process more than the actual performance; hence a measurement of stress will in other words provide insignificant insight of how crew can get better at what they do. This study can however provide several insights into characteristics that are found to be relevant for how experienced crew reflect upon their way of work, which include characteristics of the crew, the organization and the equipment. Although the used models in this study could not achieve a complete match, this is not to say that they are not relevant. There is great potential to further examine, validate and test these models more throughout.

Fourth, existing safety measures will eventually outdate in term with how the industry evolves. The strength of a theoretical framework that aims to assess issues related to safety depends upon its ability to account for the "right stuff". This study demonstrated that there are several aspects that neither of the models used in this study was capable to account for. This implies the need to update existing frameworks to make them in term with current requirements.

Limitations

This study used semi structured interviews and quantified qualitative data to run statistical tests. This will imply some limitations that can have an impact on how the results are interpreted.

Sample: Despite the fact that the interviews were able to gather a substantial amount of statements, this study had only ten participants in total and it is always relevant to ask whether this number is sufficient. The number of participants in qualitative studies always depends on the objective of the study, and most qualitative studies tend to have around 10 ± 15 participants (Robson, 2002). This study was an explorative study, and seeing the number of participants in light of the difficulties of gathering participants in addition to the time and resources available, 10 participants is not a huge setback. However, since the analysis involved quantification of statements to conduct statistical analysis, the small number of participants may have biased the results. High standard deviations on some categories, as shown in the descriptive results, indicate that some participants were more talkative than others. This may have a link to the range of experience between the participants. Some participants had only had 8 years of experience while others had over 45 years shipping experience. A more uniform group, and more participants could have given other results.

Nevertheless, the pattern in the dataset is considered applicable for this study, and it is an empirical question whether other or more participants would have given other results.

Interviews: Interviews is a flexible and adaptable method. However, the quality of the results heavily depends upon the quality of the interviews and it is important to be aware of the fact that the researcher is the primary research tool (Kvale, 1996). Interviews can be biased by the interviewers behavior and his or her ability to obtain a common understanding of what the purpose and objects of the interview is (2004). Although the interviewer in this study had adequate training and relevant experience for the chosen method, general inconsistency of each interview based on location and available time may have an impact on how the results turned out. One interviews was conducted in English, and language difficulties may also have affected the results.

The interview questions was designed with the purpose of letting the participants freely reflect what they found significant related to the way they worked. Some participants expressed difficulties of knowing what to answer. It might be that the interview questions were too general. This can also be seen in light of the relative high number of statements not accounted for as a strength, weakness, opportunity, or threat, as shown in Table 2. Much of these statements involved remarks about what demanding maritime operations was all about. This was also the nature of the first interview question, and was regarded a crucial part of getting an understanding of the topic in the interviews. On the other side, the high number of statements not accounted for in SWOT might reflect the general finding of this paper, that the participants find it difficult to relate themselves towards their way of work without including a lot of contextual information.

Unitizing: The unit of analysis in this study is based upon quantified statements. Splitting up a stream of verbalization into units or statements involves subjective judgment from the researcher. Krippendorff (Hoff, Straumsheim, Bjørkli, & Bjørklund, 2009) state that it is often hard to accomplish both reliable and semantic meaningful units at once. The findings in this study are therefore to a great extent depended upon the operatialization of a statement. There is always a possibility that other researchers would have judged a statement differently and furthermore that the frequency of statements could have been a different value. A superficial reliability check of the unitizing procedure was conducted early in the unitizing process with a few differences observed. However, a more comprehensive inter judgment reliability analysis could have examined the process of unitizing more throughout and come up with different results. Future studies that plan to use the same methodological approach should examine the unitizing reliability more throughout. Using a syntactic definition of a statement, like a paragraph or a sentence, could on the one side increase reliability. However, this could have interrupted with the semantic meaning in the text and could have affected validity of the findings. The semantic meaning of a statement is regarded more important in an explorative study.

Coding: The operationalization of a statement will furthermore also affect how the statements are coded into categories. The definition of the each category is to the extent possible based on the original definition from the paper it is gathered from. The model of expertise, based on Shanteau (1992) provides however only a small elaboration of each dimension. Hence, to increase reliability of the coding process, each category was considered value free and was tailored for this specific study. This means that a statement that contained the theme *communication* was coded in the category *communication* in PCE regardless if it was a positive or a negative feature. In addition, four of the dimensions where excluded from the analysis due to high degree of overlapping with other categories, and it was difficult to discriminate between each dimension. For instance, characteristic 7) *identify and adapt to exceptions* and 9) *adopt decision strategies to changing task conditions* are semantically quite similar and was found difficult to separate. Furthermore, characteristic 4) *simplify complex problems and the strategy* 15) *break problems into simpler parts*, is also semantically similar, and was combined. These interventions will necessarily influence with the validity of testing this Shanteau's (1992) framework.

The inter rater reliability, measured with Cohen's Kappa, was found to be acceptable in terms of the guidelines provided by Landis and Koch (1977). However, earlier studies based on the same methodological basis have reached higher inter-rater reliability, and shows that it is possible to obtain a reasonable inter-rater agreement in this kind of research. Low inter rater can imply that is can be difficult to replicate this study and come up with the same results.

Content analysis: The results from this study are based on both quantitative and qualitative analysis. There is always a possibility that the meanings and content of a statement might have been misinterpreted. Furthermore, counting the number of statements within the same general theme does not necessarily entail the significance of this theme. The absence of a certain theme is not the same as it is not relevant. However, the quantitative results must be seen in light of the qualitative results. The fact that the models was not able to account for all statements can be seen in light of the qualitative results that reveal a lot of domain-specific details. A full thematic or content analysis of the complete interviews could possibly give some valuable insights into the dataset.

Suggestion for Further Research

There exist little research that empirically tests the applicability of different theoretical frameworks that account for human behavior in complex systems. More research is therefore needed on the models we use to understand and assess the contribution of the human element in the maritime domain. This study forms a foundation for a number of directions for future research.

One direction that can be informative for this understanding is the relative importance of each category in the used models, as this gives an indication of which factors that is relevant for the studied domain. As illustrated in Figures 1 and 2 the distribution of statements across categories was uneven for both models. Since the method used in this study does not allow for a comparison of each category, future studies should investigate their relevance and make comparisons. Construction of surveys could for instance test different dimensions on a greater scale.

Survey studies could also be valuable with regard to the themes identified in the content analysis. Further research should investigate these themes in order to determine their relevance and whether they could be applied to future frameworks.

This study had participants from captains, chief officers and second officers. The impression from the interviews was that these groups tend to reflect differently about the subject matter. The small number of participants in this study did not open up for comparison between groups. A suggestion for further studies would be to conduct more interviews and make group comparisons. This can for instance give valuable input for identifying specific training needs that for each group.

Another direction for further studies is to look closer into the area of expertise. This study took an explorative approach of one framework that describe expert characteristics. It is critical to know what constitutes expert behavior before trying to measure expert performance. Shanteau's (1992) framework was able to match some of the aspects in the maritime domain, and might be a good starting point for further research. There is a huge potential for the use of expert knowledge for further development. For instance, how could expertise be transferred to the design of a ship bridge, develop better automation systems or equipment, or how could we train for expert performance in complex maritime operations in the future?

Conclusion

This study shows that neither an individual centered approach (expertise) nor an organizational centered approach (safety climate) was able to account for the majority of statements expressing reflections about work practices in demanding maritime operations. A safety climate model combined with a model of expertise was able to account for a larger part of the statements than the models could separately, but fails to cover the whole picture in this study. The residual statements revealed several relevant themes related to how the crew perform they work and is a valuable source of information to further research. The results from this study demonstrate the complexity of assessing safety and performance in complex sociotechnical systems such as a marine vessel. Relying on insufficient frameworks when assessing the human element in complex work will leave the industry less capable to make the right adjustments in the future. This implies the need for more research to better understand the dynamic interactions between the factors that shape performance in demanding maritime operations.

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Appendix A

General information letter

UiO : Universitetet i Oslo HØGSKOLEN I VESTFOLD

Informasjon om deltagelse i forskningsprosjektet "Ekspertise under krevende maritime operasjoner" – EKMAR.

Som en del av et forskningsprosjekt ved Universitetet i Oslo (UiO), i samarbeid med Høgskolen i Vestfold (HiVE), jobbes det i disse dager med et arbeid som tar sikte på å studere ekspertise under krevende maritime operasjoner. I den forbindelse ønsker vi derfor å komme i kontakt med maritimt personell, herunder offiserer, som jobber med eller har erfaring fra ett eller flere av disse områdene:

- Offshoreoperasjoner (Ankerhåndtering, Supply, o.l)
- Navigasjon og manøvrering under krevende forhold.

Målet med prosjektet er belyse hva ekspertise er i krevende maritime operasjoner. Mer konkret ønsker vi å se på hvordan offiserer opplever og tenker om sin måte å jobbe på rundt og i krevende operasjoner. Det er viktig å påpeke vi ikke er ute etter personlige egenskaper eller prestasjoner, eller detaljer rundt prosedyrer.

Innsamlet data skal benyttes til å underbygge en masteroppgave ved UiO, og inngå i langsiktig kompetansebygging ved HiVE.

Til datainnsamling vil det benyttes intervjuer. Intervjuet vil ta omkring 30 min, og vil foregå på tomannshånd. Intervjuet vil tas opp på bånd for å sikre korrekt uthenting av informasjon. All innsamlet informasjon blir anonymisert, og behandles i tråd med forskningsetiske retningslinjer UiO og HiVE er forpliktet til. Informantene vil på forhånd motta et informasjonsskriv med prosjektets hensikt og mål, samt detaljer rundt intervjuet.

Ferdigstilte avhandlinger vil være tilgjengelig for samarbeidende parter. Dersom dere kan bidra med å sette oss i kontakt med deres offiserer vil vi gjerne høre fra dere.

Har dere spørsmål eller ønsker mer informasjon er det bare å ta kontakt. Følgende personer er tilknyttet prosjektet:

Cato A. Bjørkli, *Prosjektleder, UiO*, cato.bjorkli@psykologi.uio.no, tlf: 916 09 044
Georg Giskegjerde, *Masterstudent, UiO* georggi@student.sv.uio.no, tlf: 970 10 664
Paul Nikolai Smit, *Høgskolelektor, HiVE* , pns@hive.no, tlf: 971 79 702
Synve Røine Fossum, *Stipendiat, HiVE* Synve.Roine@hive.no, tlf: 992 99 772

Vi ser frem til å høre fra dere.

Appendix B

Information letter to participants

Informasjon til deltakere i prosjektet EKMAR - Ekspertise i krevende maritime operasjoner.

Dette er et forskningsprosjekt ved Universitetet i Oslo (UiO) og Høgskolen i Vestfold (HiVE). Målet med prosjektet er å bedre forstå hva ekspertise er i krevende maritime operasjoner.

Som datainnsamling i dette prosjektet foretar vi intervjuer med offiserer. Hensikten med intervjuet er å få et innblikk i hvordan erfarne offiserer tenker om sin måte å jobbe på i krevende operasjoner. Vi ønsker å få en bedre forståelse av ulike sider ved hvordan man jobber i og rundt krevende maritime operasjoner, og hvordan dette kan ha betydning for sikkerhet og effektiv drift.

Det er ikke nødvendig med spesielle forberedelser før intervjuet, men det er fint om du kan lese gjennom og tenke litt på følgende to punkter:
1) hva du mener kjennetegner krevende maritime operasjoner slik du ser det, og
2) hva som kjennetegner din måte å jobbe på i og rundt slike operasjoner.
Intervjuet kommer til å strukturere seg rundt hva som er styrker, svakheter, muligheter og trusler ved din måte å jobbe på i og rundt krevende maritime operasjoner. Tenk gjerne hvordan din tilnærming, eller måte å jobbe på er forskjellig fra for eksempel noen som er mindre erfaren, eller har ulik bakgrunn.

Det er viktig å påpeke at dette ikke er en evaluering av personlige egenskaper eller prestasjoner. Det er heller ingen vurdering av prosedyrer. Vi er ute etter hva du tenker om krevende maritime operasjoner og hva du tenker om din måte å jobbe på i slike operasjoner. Hvis det er noe som er uklart eller om det er noe du lurer på underveis er det bare å stille spørsmål.

Lengde på intervjuene
Intervjuet tar omtrent 30 minutter.

Opptak
Vi ønsker å ta opp intervjuet på bånd for å sikre korrekt uthenting av informasjon. Opptaket vil ikke bli brukt i sin helhet, og vil slettes etter bruk.

Dine rettigheter som deltaker i en vitenskapelig studie
Du har til enhver tid mulighet til å trekke deg fra studien uten å oppgi noen grunn. All informasjon vil bli behandlet konfidensielt og alle som deltar vil bli anonymisert. Intervjuer, notater og annen dokumentasjon vil behandles og lagres i samsvar med retningslinjer fra Datatilsynet og forskningsetiske krav.

Samtykke

"Jeg har lest informasjonen ovenfor og er informert om mine rettigheter i en vitenskapelig studie":

Signatur: _

Har du spørsmål eller ønsker mer informasjon kan du ta kontakt med Georg Giskegjerde (UiO) på georggi@student.uio.no, eller telefon 97 01 06 64.

APPENDIX C

Unitizing instructions: defining a statement

What is a statement?

- A statement is defined as the (smallest) meaningful part of a sentence, a whole sentence or several sentences that reflects the informants experience and understanding of the topic of interest.

- A statement is the informant's reflection to the interviewers questions and topic of interest independent of any models and theories about the topic.

- A statement should be, to the extent possible, be comprehensible by itself and contain only one piece of information, idea or evaluation.

- Sentences or paragraphs that contain several statements (information units) should be marked as several statements even if these statement contains only a single word. If the single word is not comprehensible by itself the context will define the meaning.
  - Ex: "*It is important to have physical strength, mental abilities and a lot of knowledge to be able to work at sea*"
    The following is a statement:
    - 1) It is important to have "Physical strength"
    - 2) mental abilities
    - 3) lot of knowledge,
      to be able to work at sea.

  In other words: three statements. The context: *"It is important to*… "and *"to be able to work at sea"* gives the statements meaning, and will be included in the coding process.

- By including the interviewers question or text before or after the actual statement (idea, information), the statement gets the sufficient semantic meaning.
  - Example: If someone says "self-confidence", it can be identified as a statement, but include necessary context in order to make the statement comprehensible on its own (for instance: "Q: what is important for you? A: self-confidence")

The boundaries of a statement

- Physical length, paragraphs, the number of words or even number of sentences does not define the length of a statement. The start and ending of a statement is dependent on its content and the context. It is considered a new statement if it changes to a new piece of information or idea that can be related to the topic and question, as described above.

- The informant often gives elaborations and examples. This can be interesting information, but not necessarily a statement as such. The important thing is that if elaborations include a point that is considered a new piece of information different from the previous, then this should be marked as a new statement.

Procedure:

The interview is transcribed more or less literally from a tape recorder and is therefore presented the same way an informant would naturally talk about the subject matter. This makes it challenging to identify statements because natural speech is not always as straightforward as written texts. If in doubt of the meaning, make a note in the text.

Open the interview in a word processing program. As you identify a statement, mark each statement with a colour (for instance yellow and green) to ensure control over what is coded or not.

Write down any notes that might come useful for further analysis.