



# How do BRM-training participants understand non-technical skills?

Guro Persdotter Fjeld<sup>1</sup> · Sturle Danielsen Tvedt<sup>1,2</sup>

Received: 3 July 2018 / Accepted: 11 March 2020 / Published online: 25 March 2020  
© The Author(s) 2020

## Abstract

Non-technical skills (NTS) can be defined as “the cognitive, social and personal resource skills that complement technical skills and contribute to safe and efficient task performance” (Flin et al. 2008, *Safety at the sharp end: a guide to non-technical skills*, p. 1). This paper aims to explore how bridge officers understand and discuss the non-technical skills involved in behavior and performance of participants in Bridge Resource Management (BRM) training. A thematic network analysis is applied to transcriptions of post-simulation debriefing sessions, based on a peer observation system that encourages discussion between training participants. The five skills identified are *situation awareness*, *decision-making*, *stress management*, *verbal communication*, and *balanced leadership*, all of which are mostly found to be in concurrence with generic theory on non-technical skills. However, for each of these skills, the findings also provide examples of certain aspects where the informants’ understanding stray from generic theory and BRM syllabus. This is discussed as possible clues to domain-specific aspects of NTS at ship bridges, as well as yielding implications for BRM training.

**Keywords** Non-technical skills · Bridge Resource Management · Situation awareness · Decision-making · Communication · Leadership

## 1 Introduction

Psychologists have long been interested in factors that enhance performance and minimize the chance of errors in operational domains (Flin et al. 2008). One part of the field, broadly termed *human factors* or the *human element*, is the non-technical skills (NTS) of those who work at the sharp end. These skills are defined as “the cognitive, social and personal

---

✉ Guro Persdotter Fjeld  
guro.fjeld@hvl.no

<sup>1</sup> Western Norway University of Applied Sciences (HVL), PO Box 7030, 5020 Bergen, Norway

<sup>2</sup> University of Bergen, Bergen, Norway

resource skills that complement technical skills and contribute to safe and efficient task performance” and are thought to reduce the chance of errors, thus contributing to the prevention and mitigation of incidents and accidents when used appropriately (Flin et al. 2008, p. 1). This notion is supported by studies in various operational domains such as aviation (Salas et al. 1999) and medicine (Gordon et al. 2012; Uramatsu et al. 2017). In the maritime industry, accidents such as vessel collisions and groundings have been linked to inadequate NTS, for example, poor leadership and insufficient situation awareness (Barnett et al. 2006; Hetherington et al. 2006).

NTS are often included as a natural part of *Bridge Resource Management (BRM) training* (training designed to reduce the chance of errors and increase operational effectiveness in maritime bridge officers and bridge teams). However, recent literature reviews indicate that relatively few studies have been performed on the specifics of bridge officers’ NTS, and that there is a need for further exploration (Fjeld et al. 2018; Wahl and Kongsvik 2018). For example, Fjeld et al. (2018) maintain that both domain-specific skill categories and content are relatively unexplored, while Wahl and Kongsvik (2018) highlight the importance of a further focus on work context and crew-specific needs. Further, several studies highlight that post-simulation debriefings and participant discussions are important for simulation-based training (Fanning and Gaba 2007). However, despite the relevance, no previous study has focused on how bridge officers understand NTS during such training. A more extensive understanding of these particularities could contribute to both the scientific understanding of bridge officers’ NTS and the development of BRM training. This study aims to contribute to this effort, by exploring *how bridge officers understand and discuss the non-technical skills involved in behavior and performance of participants in Bridge Resource Management (BRM) training*.

### 1.1 BRM training and the importance of bridge officers’ understanding of NTS

The content and form of BRM training is regulated by The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) (Table II/1 and A-II/2 in STCW Code ’78 as amended) (International Maritime Organization (IMO) 2011); in addition, some national maritime authorities provide specifications to be enforced within each nation’s fleet. Guidelines including the corresponding criteria for the assessment of BRM competencies are provided. These include the ability to *demonstrate knowledge of bridge resource management principles*, including (1) *allocation, assignment, and prioritization of resources*; (2) *effective communication*; (3) *assertiveness and leadership*; (4) *obtaining and maintaining situational awareness*; and (5) *consideration of team experience*. Corresponding criteria for assessment are as follows: *Resources are allocated and assigned as needed in correct priority to perform necessary tasks*; *Communication is clearly and unambiguously given and received*; *Questionable decisions and/or actions result in appropriate challenge and response*; *Effective leadership behaviors are identified*; and *Team member(s) share accurate understanding of current and predicted vessel state, navigation path, and external environment* (IMO 2011). As indicated above, the guidelines include themes that draw on operators’ cognitive and interpersonal skills. Thus, NTS provide a natural framework for such training. *Situation awareness, decision-making, communication, teamwork, leadership, managing stress, and coping with fatigue* are a list of general skills reckoned to be of relevance to most operational domains (Flin

et al. 2008). Although the main categories of skills may be similar between domains, differences due to variations in tasks and work environment should be expected. Flin et al. (2008) highlight the importance of domain-specific exploration. In domains such as anesthesia and emergency medicine, extensive research has been undertaken to understand the particularities of the relevant NTS (Flin et al. 2008). In the maritime domain, however, it has been claimed that NTS knowledge currently in use in BRM training primarily stems from other domains (such as aviation) and even that indications of poor effects of BRM training are partly caused by the lack of adaptation of the syllabus to the maritime domain (O'Connor 2011). Some effort has been made to develop preliminary NTS taxonomies and behavioral markers (Conceição et al. 2017; O'Connor and Long 2011; Saeed et al. 2017). However, reviews in the domain have indicated that there is still a need for further exploration of NTS in this setting (Fjeld et al. 2018; Hetherington et al. 2006; Wahl and Kongsvik 2018). This could present a challenge for BRM-training providers and assessors, as it may be unclear how skill aspects such as skill contents should be understood.

IMO (2011) suggests that *approved training*, *approved in-service experience*, or *approved simulation training* is used for BRM training (in line with international regulations, BRM competencies can also be obtained through on-board assessment). Full-scale high fidelity simulations are considered a valuable training tool, as they provide a controlled and safe way to provide experience away from the potential risks and consequences of real-life situations.

Although much is still not known about which instructional practices is best suited for simulation training in order to ensure learning and development (Sellberg 2017), studies on simulation-based training indicate that much of the actual learning occurs during participant discussions, for example, during post-simulation debriefings (Fanning and Gaba 2007; Shinnick et al. 2011). Dakic, Milinic, and Tripovic (2014, p. 5) maintain that one key feature of BRM training is to “actively promote discussion during the workshops (rather than lectures) and in the active discussion, experience and opinion sharing after each simulator exercise.” Thus, together with the shared experience of the scenarios performed, bridge officers’ understanding of the required NTS should be considered a core prerequisite of learning. Despite the apparent relevance, so far both the BRM debriefing session and the particularities of bridge officers’ understanding of relevant NTS, and how these are talked about, remain unexplored in scientific studies. Thus, this study targets how bridge officers participating in BRM training understand and talk about NTS. This study is not intended as a complete taxonomy of NTS used by bridge officers, but rather it offers a look through the “window” of the bridge officers’ understanding of these skills. Looking through this window of understanding may offer insights into the domain specifics of NTS at ship bridges by noting the foci and depictions of aspects of the NTS made by the participants and comparing this to the existing BRM syllabus.

## 2 Methods

### 2.1 Data and participants

A convenience sampling strategy was used, recruiting bridge officers to the study through their participation in a BRM training course at Simsea simulation center. All bridge officers enlisted in a period from August to December 2014 were invited to

participate. This period included 13 complete courses, each with 12 (in rare instances 11) course participants. The study included a total of 162 bridge officers, aged from about 25 to 67: 157 men and five women, employed in Norwegian shipping companies in the offshore-related commercial fleet. The informants worked on board various types of vessels (from small tugs to big tankers) at the time of the data gathering. Rank and tenure varied from third officer to captain and from a couple of years to over 30 years of experience.

The course language was Norwegian, and most of the officers included had Norwegian as their native language. In this manner, informants could be claimed to reflect a common cross section of bridge officers employed in Norwegian offshore-related shipping companies operating in the North Sea, which employ mostly Norwegian or Nordic bridge officers.

The final data material consisted of audio recordings from post-simulation debriefing sessions. Altogether, 54 feedback rounds (27 full debriefing sessions, each with two performing teams, and two sets of observers) were recorded using two hand-held digital audio recorders (Edirol R-09), transcribed using Microsoft Word®, and analyzed using QSR NVivo 11® software.

## 2.2 Background—overview of BRM set-up and content

The specific content and set-up of teaching methods and scenarios vary between training centers. The BRM courses accessed used a set-up, in which a debriefing session followed each simulation. As mentioned, this study is concerned primarily with the contents of these debriefings. However, to offer the reader an overview, brief descriptions of the Simsea BRM training set-up, simulator specifications and simulation content are given below. These are followed by a detailed description of the debriefing setting.

### 2.2.1 Simulations and scenarios

The BRM simulations were performed at Simsea simulation center. High fidelity Kongsberg *Polaris*® and Kongsberg *K-sim*® bridge simulators provided a full-scale replication of the functional layout and physical capability of the bridge interior and a virtual representation of the outside environment (such as weather conditions and time of day or night). The physical behavior and movement of the ship are visually produced in six degrees of freedom and are calculated from realistic mathematical models, that incorporates effects of engines, rudders, current, wind, etc. This specific course contained three different scenarios: (1) *familiarization*, (2) *crisis*, and (3) *search and rescue (SAR)*. The aim of the familiarization scenario was to give participants time to familiarize themselves with the simulators (e.g., navigational equipment and radio equipment) and the training situation (e.g., getting to know the other team members). The debrief following this scenario was excluded from the study, as it was not directed towards NTS-related performance. Debriefings following crisis and SAR scenarios were included, as they were based on peer observation of NTS skills and behavior. In the following, the content of each scenario is briefly presented.

**Crisis** The two bridge teams perform in “parallel universes” (meaning that they perform the scenario simultaneously but do not interact with each other). Starting the exercise, each bridge team faces a routine operation: loading containers from a supply vessel onto an oilrig. Mid load, the vessel experiences an engine blackout and a personnel injury that requires the coordination of crisis and evacuation resources. Although some of the participants have experienced certain parts of the events of this crisis scenario (such as a blackout), they have not experienced this particular situation, and the level of crisis is not routine for them.

**Search and rescue** The two bridge teams perform the scenario in the “same universe,” allowing them to interact and cooperate. Each vessel performs a routine transit leg when interrupted by a distress call, to coordinate a search effort to locate a target (rescue raft) in the water. This scenario calls for interaction between the two bridge crews, in a non-familiar situation for most bridge officers, meaning that the officers are typically not very proficient in establishing and coordinating search patterns, thus rendering the radio communication related to this task challenging. A rescue coordination center was included in the scenario, but on-scene-coordination was left up to one of the participating simulated vessels.

### 2.2.2 BRM training set-up—simulation and observation

As mentioned, in the course we got to access, each simulation was followed by a debriefing session, set up after a peer-feedback system where observers gave feedback to participants. The debriefing sessions were led by professional facilitators. This approach is common in simulator training (Fanning and Gaba 2007; Tvedt 2019). Following standard BRM training procedures at the simulation center each scenario was run twice, however with tweaks and dynamic situational responses to actions and decisions taken in each run to maintain an optimum level of challenge and to avoid feelings of repetition. The order of observer/participant was switched between scenarios (i.e., those who acted as observers first in one scenario, acted as participants first in the next scenario). Thus, each person was allowed to both participate in and observe each scenario type. Throughout the text, the following distinction is used: *Participant* refers to the role that a person has when they have been playing the simulation. *Observer* refers to the role that a person has when they have been observing an exercise. *Informant* is used to describe any individual that partook in the research (both participants and observers). Furthermore, throughout most of the text, the term *leader* is used to describe the bridge leader—the one performing leadership. This is because in real-life settings, several different of the regular bridge team roles can inhabit the leader role (Officer of the Watch OOW) at any given time, depending on aspects such as shifts etc. That is, the leader role can be inhabited by different team members—not necessarily the captain. However, in the quotes presented in the result chapter, the term *captain* is used, as this was the leader title used for all scenarios during the BRM training. The BRM training course that we got to access for this data collection did not include extensive training of observers. However, all informants did undergo a brief training session in observing and giving feedback prior to the simulations. Although this approach may not ideal for training observers in using any tool for precise assessment of NTS skills

and behavior, it works well for the purpose of the current study, where the relatively free discussion about the relevant NTS is the main point of interest.

The observers followed the simulations from an adjacent room, via monitors, streaming video from cameras covering the bridges from four angles, and headsets, with audio from wireless microphones worn by each scenario participant.

### 2.3 Debriefing sessions

Following each simulation, both sets of participant bridge teams and observers took part in one shared debriefing. During these sessions, observers evaluated “their” participant team’s performance, followed by a collective discussion of salient NTS-related issues, in which all participants and observers took part. Each debriefing session amounted to 30 min.

The BRM-training framework and simulations performed provided the informants with a common frame of reference, allowing the debriefing sessions to be steered by informants themselves to a large degree. However, certain steps were taken to facilitate peer observation, feedback, and topic relevance of the discussion. One such step is the use of broad, single word cues for observers to use during observation, derived from the BRM syllabus and STCW guidelines for BRM training (IMO 2011): *leadership, communication, cooperation, situational awareness, planning, decision-making*. The cues were given to the observers in the form of a sheet that they could use for making notes during observations. Intended to guide observations and debriefing sessions towards the general area of NTS, they provided no explanation of the skills, expected skill contents or standards of behavior. Observers were instructed to interpret these as mere suggestions and to note down anything and everything of importance and interest related to the BRM performance.

Another step was the use of the previously mentioned discussion facilitators (often one of the authors of this study), whose role was to keep the discussion on track and encourage precise feedback, without steering the content of the discussion. One example of such facilitation follows:

Observer: ...The communication and cooperation were superb... Nothing negative as far as I’m concerned.

Facilitator: Mm, was there anything in particular that made it ‘superb?’

### 2.4 Transcription and analysis of data

#### 2.4.1 Transcriptions

In order to preserve the richness of the data, audio files were transcribed verbatim in great detail. As several research assistants were involved in the transcription, consistency across transcribers was ensured by (1) the development of a detailed codebook, describing how various audio cues should be represented in the text (e.g., how to differentiate between observers and simulation participants in the text); (2) the performance of a test, in which different transcribers’ interpretations of the same audio file were compared word for word.

## 2.4.2 Analysis

A thematic network analysis was applied to the transcribed data. According to Braun et al. (2014), this is a theoretically flexible approach suitable for identifying and analyzing themes and patterns within qualitative data. The analysis followed the recommended step by step strategy (Braun and Clarke 2006). All parts of the data analysis were performed by two researchers in collaboration. In the case of any dispute, agreement was reached through discussion.

Braun and Clarke (2006) suggest that researchers should take great care in familiarizing themselves with the data. The authors gathered all data themselves and functioned as group facilitators during the debriefing sessions, allowing close familiarization at an early stage. Following transcription, the next stage of analysis was to go through the text in detail, deriving and labeling *basic themes*. Each text excerpt was coded for all relevant basic themes, meaning that one paragraph could have several basic themes. One example of a basic theme is: *It is important to communicate frequently*, based on statements such as the following:

Observer: The communication was good. You [the bridge team] talked all the time, kept it going, updated each other frequently. That is really important; that's all there is to say.

Next, the basic themes were grouped together into *organizing themes*, according to content and meaning. Our example basic theme was included in the organizing theme: *frequency and amount of communication*. In the final steps of the analysis, basic themes and organizing themes were further reinterpreted in the light of each other—deriving the overarching *global themes*. Thus, our example basic theme and organization theme were finally understood as a part of the global theme *Communication*.

In accordance with Braun and Clarke (2006), the analysis took the form of a *recursive* process, in which the researchers moved back and forth between data, basic themes, organizing themes and global themes throughout the process. During the write-up of the paper, the authors selected and translated (and re-translated when necessary), exemplary quotes. In this process, the authors took great care to ensure that no meaning was lost from the text.

## 2.5 Ethical considerations

Relevant ethical approval was granted by the Norwegian Data Protection Official for Research (NSD). Before data gathering began, all potential informants were informed about the project, including their right to withdraw at any time. Those who opted to participate signed an informed consent form. Transcription assistants signed confidentiality agreements, and all audio data were anonymized in transcriptions to ensure the anonymity of each participant and the shipping company represented.

### 3 Results

The thematic analysis identified five global themes: *situation awareness*, *decision-making*, *stress management*, *communication*, and *leadership*. Perhaps unsurprising, these global themes reflect main topics in the BRM syllabus. However, the skill content identified is indicative of the informants' using their own experience, interpretation, and vocabulary. Interlinkage of skills and the salience of the interpersonal aspects of skills were also identified as important. Each global theme, with its corresponding organizing themes, is presented in the following. An overview of the results is presented in Table 1.

#### 3.1 Situation awareness

Within situation awareness, *general lookout* and *targeted information gathering* constitute two main *strategies for building and maintaining an overview*, which is the first organizing theme. The second organizing theme *distribution of attention resources*—a balance between maintaining an overview and focusing on single tasks—incorporates the distribution of efforts at both the individual and team levels. The third organizing theme is *proactivity: anticipating and managing the future*, in which informants highlight the importance of being able to anticipate and manage future events.

##### 3.1.1 Strategies for building and maintaining overview

*General lookout* is described as a non-targeted scanning, where attention is moved between different information sources (e.g., looking at instruments or out the window) that could offer information relevant to understanding the situation at hand.

The second strategy identified is a more *targeted information gathering*: purposefully targeting specific pieces of information that are not necessarily directly available. This strategy aims to update one's awareness on *specific* aspects of the environment. This could take the form of double-checking a specific instrument, or it could involve probing to see whether there is any information that supports or counters the current worldview. One example of the two strategies used in a dynamic fashion is shown in this passage:

Captain: ...The helmsman, used the binoculars actively – to look specifically for potential hindrances – to make sure that we were clear backwards. The rest of us looked around too. I tried to pay attention in a more general sense – looked around – at the traffic situation and so on.

In this instance, the participants find it necessary to use both strategies. As they are aware of the potential difficulties of maneuvering in this particular area, one team member checks for specific hindrances, while the others maintain a more general lookout.

##### 3.1.2 Distribution of attention resources at individual and team levels

The next organizing theme is the importance of distributing attention resources throughout the team. Although overview is considered important, informants indicate



**Table 1** An overview of the results

Global themes	Organizing themes	Brief description of skill, skill content, and exemplary behavior as described by informants
SA: keeping an overview	Strategies for building and maintaining overview	General lookout is used to scan environment, e.g., a team member can look around to gather an overview of the full situation. Targeted information gathering is used in to gather information from specific sources. For example, a team member uses the binocular to scan for specific hindrances
	Distribution of attention resources on individual and team level	SA is dependent on both the individual operators' skill, and on the team's ability to distribute attention resources amongst the members. Individual team member can concentrate fully on one task, e.g., maneuvering, if others keep the overview. It is considered dangerous if all team members focus on one thing (e.g., looking at the ECDIS), and overview is not maintained.
	Proactivity: anticipating and managing the future	Ability to envision situational developments, and to proactively identify and prepare available resources. In addition to identifying future risk and threats, considerations of workload and own capability to meet demands are included. Future workload pressure is managed by either cognitive or practical preparation or by early mobilizing of resources outside the bridge team. For example, bridge team discuss how situation may change, including identifies potential dangers, and resources that can be used should anything happen.
Decision-making	Decisions based on rules and procedures	Knowing and following procedures can provide framework for action in a pressured situation, e.g., procedure for alerting after a crisis. Participants consciously evaluate whether the procedure offers a sound and safe solution.
	Analytical decision-making: discussing the options	An analytical form of decision-making, including an identification and evaluation of options before a decision is made. The leader includes team members in a discussion relating to a decision. This is particularly salient when the team lack competence or experience in the matter at hand, or when the situation is unclear or novel. The leader still has decision power and final say in most matters, but is praised for including team members.
Stress management: importance of keeping a calm bridge	Keeping a calm bridge—protecting cognitive performance	It is considered vital to remain calm on the bridge. Each team member must stay calm in order protect cognitive performance and ability communicate clearly. In stressful situations, such as an emergency, all team members keep a calm demeanor and communicate in a calm and clear manner. The

**Table 1** (continued)

Global themes	Organizing themes	Brief description of skill, skill content, and exemplary behavior as described by informants
Verbal communication	Stress' contagiousness between team members	informants do not discuss how the internal state is controlled, but focus on the outward projection of calmness. Visible stress is considered contagious between team members, and should thus be avoided.
	Resistance to misunderstanding	Communication must be clear and unambiguous in order to be resistant to misunderstandings. During maneuvering and performing operations, communication between team members, and with other units is performed using language that is simple, clear and precise. Use of double loop communication is advised. Communication with external units may require particular consideration and forethought to ensure the message is easily understood.
	Frequency and amount of communication	Communication should be frequent and continuous. During operations, team members keep each other updated, and coordinates effort through frequent pushing of information. However, too much communication can become distracting. During "tight situations," such as emergency exercises, one can risk being overwhelmed by the sheer amount of communication and information. Capacity to take in and understand information should be preserved.
	Whole team participation and assertiveness	The whole team participate actively in communication, and speak up when needed. For example, the helmsman reminds the leader of aspects that he/she forgets
Balanced leadership	Managing team and task while maintaining an overview	The bridge leader keeps an overview. He/she manages team effort and tasks, not overloading any one team member. Task distribution functions best when it balances between rigid responsibility and flexibility when needed. For example, the leader delegates and communicates responsibilities, and changes in these clearly.
	Balanced authority	The leader balances between issuing clear orders and inviting team members' input. For example, the leader invites or asks for team members' input when appropriate, but still manages to issue clear authoritative orders when needed.
	Running a calm bridge: hindering and mitigating stress	It is important that the bridge leader remains calm. A calm leader is perceived to affect the team members' stress levels in a positive manner. The leader uses demeanor and verbal cues to help team members manage stress. For example, telling team members to take

**Table 1** (continued)

Global themes	Organizing themes	Brief description of skill, skill content, and exemplary behavior as described by informants
Overarching skills	Leadership-specific NTS responsibility	their time when performing essential tasks during a pressured situation. The leader bears a particular responsibility that exceeds that of the other team members in certain aspects when it comes to keeping a calm bridge (stress management) and keeping an overview (SA) as well as in facilitating analytic decision-making.
	Communication—allows interpersonal NTS performance and behavior	Communication overarches the execution of the other skills; it is used as a tool to effectuate other skills. For example, communication is used during analytical decision-making that involves several team members.

that, in order to perform unfamiliar, complex and demanding tasks that require full attention, individual team members occasionally, momentarily, make a conscious trade-off to concentrate fully on a single task, at the expense of losing the situation overview. In such situations, *team* attention resources must be distributed so that other team members maintain sufficient overview. In the following quote, one observer exemplifies such distribution.

Observer: Yeah, I would have liked to see someone taking the opportunity to take a step back and get the overview of what was going on. But, in relation to cooperation and leadership, it was working, because [the helmsman] really had enough with maneuvering the vessel. And while [the helmsman] was concentrating on this, the rest fell on [the captain]. Thus, you [the team as a whole] managed to keep up.

The observer indicates that he would have preferred one team member to have taken the opportunity to take a step back and focus on maintaining the complete overview. However, when that proves challenging due to the number and complexity of tasks, he praises the team for distributing tasks and attentional resources so that the overview was maintained. One single team member can be submerged in a task that requires full attention—as long as someone else maintains lookout. One explanation for this can be the notion that a single team member can relatively easily be updated by the others (depending on communication skills, specifically information pushing).

It is, however, considered dangerous for all team members to be preoccupied, with no one taking care that the team overview is maintained. In the following example, an observer shows his concern that all team members were immersed in the same task (maneuvering the vessel away from an offshore installation):

Observer: There was one occasion...when you were leaving [the rig], you were all concerned with the maneuvering – you all stood close together, figuring out how to push the buttons while you backed out...?

Captain: Yes, we used the thrusters.

Observer: Yes, but no one was checking...for example the waters behind you...whether there was anything there? There could have been other vessels or such behind you.

Captain: Yeah, that is true...that was bad.

The observer indicates that he suspects that the team's overview and ability to discover important aspects of the situation was lost, as all team members focused on a single task. Through these examples, we see the contours of how informants understand situation awareness as dependent on both the effort and skills of the individual, as well as the distribution of attention resources throughout the team, providing an interpersonal aspect of situation awareness.

### 3.1.3 Proactivity: anticipating and managing the future

The ability to envision the potential developments of a situation and to prepare accordingly was identified as a key aspect of the informants' understanding of situation awareness. In the words of one observer:

Observer: They were very diligently focusing on what could happen: what if the wind increases, is there enough engine power to mitigate that...do we have any back-up resources if the situation escalates? To me, this means that they were proactive – they had good contact with the situation, so to speak.

Highlighting the importance of being “proactive” and in “contact with the situation,” the observer praises the bridge team for imagining and discussing possible future scenarios, including relevant worst-case scenarios. As the previous example indicated, anticipations are tied not only to situation development but also to evaluations of one's own abilities and the available resources.

According to our informants, identifying and preparing potential resources at an early stage can help mitigate future pressure. Examples of “preparing resources” could be mobilizing the crew for extended lookout, preparing the mob boat for launch so that it is ready to deploy if needed and so on. One observer comments:

Observer: On situation awareness, when the view declined, you talked back and forth whether or not to scramble an extra lookout: should we get an extra crew member to the bridge? I thought that was excellent, since these discussions can raise your consciousness on the essential aspects that can help you stay at the forefront of a potential escalation.

Such early identification and anticipation of potential problems and resources can help mitigate surprises, through cognitive and practical preparation that can ease future pressure and workload in the potential upcoming intense situation. Another observer elaborates:

Observer: When it comes to situational awareness...I think they did a good job with mobilizing the rest of the crew early: informing and preparing them so that

they were ready to pitch in when needed. Then, they [the bridge team] did not have to do the extra work [mobilizing the crew] later... So, they were very proactive in that situation.

The above quotation indicates that proactive identification and preparation of resources is an investment that can mitigate workload and improve ability to cope when (and if) the situation escalates. One exchange between an instructor, a bridge team member and an observer further exemplify the benefits of remaining in a proactive state.

Captain: We always try to operate proactively – that’s the philosophy!

Instructor: Is that easy to do?

Captain: No, it is not.

Observer: But, if you do not, there is a tendency to get stuck in a vicious circle. It feels good when you get the hang of it – it just flows.

As the example above indicates, it is preferable and comfortable to be able to remain proactive, though it may not be easy. If lost, proactivity is hard to recover, placing the bridge teams in what the observer calls a “vicious circle,” possibly due to the increased task load and complexity that may follow unanticipated escalations.

### 3.2 Decision-making

For decision-making, two organizing themes were identified: *decisions based on rules and procedures* and *analytical decision-making: discussing the options*.

#### 3.2.1 Decisions based on rules and procedures

One recurring theme throughout the debriefing sessions was whether decisions were in line with regulations and procedures. This indicates that informants’ understanding of decision-making incorporates the importance of knowing and following relevant regulations. One participant explained the benefits of following a procedure for alerting about the important instances right after an emergency:

Captain: It is standardized – boom boom boom – so you know what to do. The three messages go out like A, B, C. What happened – and then you add more info as you go. That is the first thing you do. Follow the procedure for alerting after a crisis – and then you have crossed that off your list.

The above quotation indicates that the participant appreciates this procedure, as it provides a set framework for action that can be helpful. However, our results also indicate that the informants consciously evaluate whether the relevant procedures offer a *safe* solution to the problem. In the following example, informants discuss a breach of procedure for entering the 500-m zone, in order to evacuate a badly injured person. The performing team does not get an immediate reply from the rig for the evacuation:

Observer: Well, the ones on board understood the gravity of the situation. The guy was badly hurt and needed to be evacuated. But when they attempted to get

help, there was no helicopter nearby. They waited for the helicopter, but then they decided that it was taking too long. When they decided to approach the rig instead, they waited for a reply and confirmation that they were allowed into the 500-meter zone. In my opinion they waited too long before they went in. I would say that if they [the rig] do not reply in such a situation, I would not give a damn about them. If I was sure that I could approach the rig safely, I would just inform them over the VHF that I was going in... This is life or death. Just go in, if you think you are able to approach safely.

The observer points to the fact that lives are at stake and that the potential consequences of following the procedure, namely waiting for a reply from the rig, could be grave. However, the observer highlights that, for him/her, this decision would be dependent on the performing team's certainty that they could approach the rig in a safe manner.

### 3.2.2 Analytical decision-making: discussing the options

The second decision-making theme is a more *analytical approach*, characterized by the identification and evaluation of options before the decision is made. Our informants are clear that the leader has the final say and decision power in most matters. However, as discussed elsewhere, the inclusion of team members' opinions is understood as a key part of the leadership skill, and discussion amongst team members is seen as a vital element of decision-making. One observer comments:

Observer: I thought they had good discussions – the three of them together – before they made decisions. This was not a so-called 'one-man show'.

The comments of this observer refer to an analytical decision-making process that takes an interpersonal form, in that participants generate and discuss different solutions—and sometimes even decide—together.

As the following example indicates, however, the process including several team members can be a time-costly affair. Some participants reflect:

First mate: Yeah, it was all right, except that there was a bit of back and forth there for a while.

Instructor: Were all team members included in the discussion?

Captain: It might have been easier if there were, if they (the bridge team) were fewer people...I do not know. But, as it was, people gave input on what they thought, and then I had to make the final decision on what to do...So, everybody had their say...Nobody...well, at least, I did not have any experience with this particular...I do not know about the others...

First mate: Me neither.

Captain: So, there is something about that, right? If anyone had been experienced in these things, we could have used that to get going!

The above quotation indicates that the team considers this analytical approach somewhat time-consuming. However, the leader chooses to include the team members, as

he/she him/herself lacks experience in this particular matter. Including the team members in the process allows their experience to be used in the field.

### 3.3 Stress management—the importance of keeping a calm bridge

The *importance of keeping a calm bridge—protecting cognitive performance and stress' contagiousness—the interpersonal effects* are the two organizing themes that comprise *stress management—the importance of keeping a calm bridge*.

**Keeping a calm bridge—protecting cognitive performance** One salient theme is keeping a calm bridge. The informants highlight that stress can cause confusion and affect performance negatively. This is exemplified by the following exchange between an observer, an instructor and a captain:

Observer: They stayed calm. That was very good.

Instructor: How important is it to stay calm?

Captain: I think that is very important.

Instructor: Why is it important?

Captain: Well, to calm down the situation. If people start to stress and run around, it can easily cause all sorts of confusion and problems...so I think it is really important to stay calm.

The informants indicate that it is vital to maintain a calm bridge, as visible stress can cause “confusion and problems.” We interpret their words to indicate that he considers stress as detrimental to performance. Another observer’s words support the linkage between stress and other NTS, as he comments on how clear communication is linked to a calm bridge and the absence of “franticness”:

Instructor: What did you think of the communication here?

Observer: I thought it was good.

Instructor: What was good about it, then?

Observer: They cooperated well – giving clear messages.

Instructor: Clear messages made the communication good?

Observer: Yes. There was a calm ambiance at the bridge. No franticness and..., yes, they understood each other...

We understand this quote to indicate that the observer links a calm ambiance on the bridge with the ability to communicate clearly and without misunderstandings.

#### 3.3.1 Stress' contagiousness between team members

According to the informants, overtly displayed stress has a tendency to spread throughout the team. One example comes from an observer who shares his/her experience:

Observer: [It is dangerous] when people around you start getting nervous – that's contagious.

Group facilitator: Contagious?

Observer: Eh, one person starts cackling and the second person starts cackling – and the third person starts pissing himself – and then it gets even worse.

Informants highlight that stress—specifically the display of stress—should be avoided, as it is both detrimental and contagious. The informants do not go into detail regarding the strategies they use to manage stress once it occurs. However, stress *management* is included as part of the leadership skill and is discussed thoroughly elsewhere.

### 3.4 Verbal communication

The informants discuss some general features that describe the quality of communication regardless of the communication's intended function. The first organizing theme presented in the following is *resilience to misunderstanding*, in which we also see glimpses of different norms relating to intra team communication, compared to communication with external actors. The second theme described is the *amount and frequency* of communication. The final theme is *whole team participation and assertiveness*, meaning that all team members should contribute and speak up when needed.

#### 3.4.1 Resistance to misunderstanding

The informants highlight that communication must be precise, clear and unambiguous, to be resistant to misunderstandings. One observer comments:

Observer: What characterizes good communication is that the information transferred is important. It is simple, clear and precise. Short messages and no misunderstandings.

Instructor: How would you say that one could prevent misunderstandings?

Observer: The receiver must ask, if anything is unclear. If everything is communicated clearly and understandably, they confirm. Closed loop.

The observer indicates the importance of brief and concise communication, and highlights that the receiver should contribute to avoid misunderstandings through repeating messages—and asking if anything is unclear.

Our informants indicated a difference between how they understand intra team communication and communication using communication tools such as Very High Frequency (VHF) and Ultra High Frequency (UHF) radio. One observer advises the team of participants:

Observer: In certain situations, you have a lot to say – a lot of information. So, really, it's like: how can we say this in a good way? So, alternatively...Maybe it is an option to team up on the bridge and plan how we can send this information in a good way – what do we do? Plan the communication before you send it.

We interpret this to mean that our informants consider communication with externals as more vulnerable to misunderstandings than communication within the team, as he/she advises the bridge team to make an effort to *plan* the external communication amongst themselves before sending it out, to minimize the chance of misunderstandings.



### 3.4.2 Frequency and amount of communication

The informants seem to agree that frequent and continuous communication is important. In the words of one observer:

Observer: The communication was good. You [the bridge team] talked all the time, kept it going, updated each other frequently. That is really important; that's all there is to say.

The above quotation is one of many examples of the importance of keeping each other updated in this manner. However, informants also indicated that they perceived a certain balance between *enough* (frequent and continuous as mentioned above) and *too much communication*. One participant comments:

First mate: One challenge in 'tight' situations is the communication part. It could easily become horrendous amounts of talk – from all sorts of channels – way too much to concentrate on anything.

We interpret this to indicate that, although frequent and continuous communication is understood to be vital to performing operations, he/she fears that it can easily become "too much," depending on the pressures of the situation. The above quotation is an example of a certain balance between having access to relevant information and continuous updates and being overwhelmed by too much input. The latter could affect the individuals' capacity to take in and understand the essentials. This highlights the importance not only of having access to information but also of maintaining the capacity to actually take in and understand this incoming information.

### 3.4.3 Whole team participation and assertiveness

The informants indicate that it is important for the whole team to participate actively in communication. One participant is praised for reminding the leader of certain aspects when he forgets:

Observer: It worked well, you worked within clear roles: the captain was the captain, and the helmsman was the helmsman. The helmsman reminded the captain of a few things that he forgot or did not think of – that was great, I thought.

The quotation exemplifies that it is considered a shared responsibility to bring forward all relevant information, including the responsibility to "speak up" (when potential danger, e.g., a faulty decision or something else "wrong" is perceived). One participant indicates that he expects the others to speak up if he/she makes a poor decision:

Captain: I prefer to share what I'm thinking and doing. Because then the others know what I'm planning. And I have to be able to trust that, if what I do is wrong or dangerous, they'll let me know.

Speaking up and contributing is frequently referred to as positive during debriefings. However, it is also recognized that it can be difficult to do so, especially if the leader is at fault. One observer comments:

Observer: It can be hard to criticize someone above you in the hierarchy – that is ingrained in us all, I think. It is easier to correct someone below – or at the same level as yourself. That, I think we all can agree on. Even though they say that they want to know.

As further explored in Section 3.5.2, the leader's opportunity to invite and encourage team members' participation and contribution is also evident in the findings on leadership.

### 3.5 Balanced leadership

Under the global theme, *balanced leadership*, the first organizing theme is *managing team and task while maintaining overview*. Further, our informants describe a preferred *balanced authority* leadership style, in which the leader balances between giving clear orders and inviting team members' input. This is not understood as a weakening of the leader's role but as a balanced execution of what is fundamentally an unquestionable authority. The final organizing theme, *running a calm bridge—handling and hindering stress*, is explored, focusing on the special importance put on leaders' stress management and their ability to affect the stress level of the team in a positive manner. As indicated, parts of the leadership skill are similar to the content of other NTS, albeit placing specific demands and responsibilities on the leader. Thus, as discussed in Section 3.6.1, we take this to mean that informants understand leadership as an NTS which overarches certain of the others.

#### 3.5.1 Managing team and task while maintaining overview

One salient theme, when it comes to leadership, is the leader's responsibility to manage the team and coordinate efforts so that tasks are performed. According to our informants, task distribution functions best when it balances a relatively rigid set of responsibilities and flexibility to change these tasks and responsibilities when necessary. One important prerequisite for this balance to work was identified throughout the debriefings: clear and communicated/stated role- and task distribution: all team members should be updated in a timely way regarding who has which responsibilities and rights. In the words of one observer:

Observer: I thought the tasks were distributed in a good way. It was calm, and the captain was alert. They helped each other and repeated all communication and orders – so that everybody knew what was happening, and who was expected to do what.

The previous quotation also indicates that the informants understand good task distribution to be dependent on an alert leader. Our informants seemed to include, as part of the leadership skill, the coordination of tasks in such a manner that no one team

member is overloaded. This demands a certain overview of the situation as a whole and of the separate tasks and responsibilities of each team member. One example of this is this first mate's comment on the leader's effort:

First mate: It worked very well in the aspect that the captain had control and gave me input all the way, even though he kept an overview. I had a lot [to do]. What do I do, what do I do next, and I have to pay attention to this and this...I got a little caught up, so it was great that the captain came over and helped. He/she gave me input: "Now you do this", "Now you do that", so I did not lose track.

Here, the first mate praises the leader for noticing that he/she was falling behind and initiating helping. This is an example of how the leader manages to *zoom in and out* between the 'micro' levels—tasks performed by each individual team member—and the 'macro' levels—the situation overview and the collective needs of the whole team.

### 3.5.2 Balanced authority

Our informants seemed to understand leadership authority (and the display of this through communication) as a balancing act. On the one hand, leaders are praised for giving clear and "undisputable" orders. One observer gives feedback to a leader:

Observer: When it comes to leadership – it was calm and nice. That is good. However, you were the leader – I thought you could have been even clearer. Managed a bit more. "Do this", "Do that". That is what I think.

The informant's comments indicate that giving clear orders is an essential part of the leadership skill. On the other hand, according to our informants, leadership also includes inviting and encouraging team members' input. One example of the latter comes from a first mate, who expresses his appreciation of the leader's inclusion of team members:

First mate: The captain asked, "Have we forgotten anything now?" That triggers the rest of us to think a bit extra – and to contribute...So that was good.

The quotation indicates that the informant values the leader's effort to include team members. Also, he/she expects that such verbal cues—indicating that input is welcome and valued—has a positive effect on the team members' active participation. The leadership skill is understood to include both these aspects. Thus, due to the nature of changing operational demands, it is certainly a key aspect to know when each is appropriate. The next example comes from an observer, who praises the leader for managing such a balance:

Observer: I have one thing to say – one thing he [the captain] did, that is not always done. The captain asked loudly, "Is there anything else we need to do?" He/she asks for input. He/she is the captain, so in that aspect he/she is the one in charge. He/she invites people to contribute but still manages to say clearly, "This is what we do. Point-blank." If you have a good bridge team, they will contribute

anyway, but there is no guarantee. Asking out loud is something special. It is a good idea, then you can get contributions that otherwise would be lost.

### 3.5.3 Running a calm bridge: hindering and mitigating stress

As described previously, stress is considered both detrimental to performance and contagious; teams that manage to maintain a calm bridge are praised for this. Further, it seems that the informants consider the leader's ability to keep calm specifically important. A calm leader is understood to affect team members' stress levels positively. Further, the informants indicate that the leader has the opportunity to use other tools to affect the bridge team's stress levels. One observer comments on how the leader could counter a situation in which a team member is highly affected by stress:

Observer: If you [the captain] say something in a calm manner, that can help the situation. If that does not help, then [the] people [that are stressed] need to leave the bridge...

The observer highlights the perceived gravity of very high stress levels in individual team members on the bridge. He/she fears that the stress will spread throughout the team and have a detrimental effect on performance. However, by showing a calm demeanor and speaking in a composed manner, the leader can attempt to calm the situation.

The following passage exemplifies how one leader uses both a calm demeanor and direct verbal cues to avoid and mitigate stress in the bridge team:

Observer: It seemed the rig was very eager to get started, pressuring you a bit to hurry.

First mate: Yes. When he/she wondered what we were doing. We tried to get control of the situation.

Observer: Yes. You [the captain] did not let it stress you. You seemed calm, and you told the team to calm down and to take their time. That is important.

Captain: Yes. I did not want them to stress. Safety first.

In this instance, the leader affected the team directly, reassuring them both by modeling calm behavior and with verbal instruction in the form of orders.

## 3.6 Overarching skills

As indicated in several of the previous result sections, the thematic network analysis indicates that certain NTS are understood to be closely linked. In particular, *leadership* and *communication* seem especially close to, and to some degree overarching, the other skills.

### 3.6.1 Leadership-specific NTS responsibility

When it comes to the leadership skill, one example is the link to the importance of maintaining a calm bridge. Another example is the indication by informants that the

leadership skill includes specific responsibilities when it comes to situation awareness and to maintaining an overview. Interestingly, the overarching leadership skill aspects are understood as important for any team member. However, the leader is considered to bear a *specific* responsibility that exceeds that of the other team members in these aspects. Similarly, leadership is connected to decision-making and communication. On one hand, the leader should invite and encourage team members' input, but he/she should be responsible for the timeliness of decisions, including taking decisive action without discussion when necessary.

### 3.6.2 Communication—allows interpersonal NTS performance and behavior

*Communication* is understood as overarching the other NTS, as it allows information flow and coordination amongst the team. It is interlinked with execution of the interpersonal skill leadership but also with the skills usually considered cognitive: situation awareness, decision-making and stress management. One example of this is the apparent link between communication and analytical decision-making, of which discussion and exchange of ideas are central aspects. Another example is the distribution of cognitive resources between team members. When team members exchange overview for concentration on single aspects, communication between team members—both before and after—is vital. The informants, however, discuss the quality of communication as something relatively separate, drawing on the importance of the communication being clear, understandable and resilient to misunderstandings, regardless of its functions.

## 4 Discussion

As mentioned, the aim of the present study was to explore *how bridge officers understand and discuss the non-technical skills involved in behavior and performance of participants in Bridge Resource Management (BRM) training*. As presented in the previous chapter, *situation awareness, decision-making, stress management, communication, and balanced leadership* were identified as key skills. Our findings indicate that the identified skills and skill content correspond to a large degree with current NTS/BRM theory. However, certain aspects reflect the contours of the bridge officers' own understanding. For example, results indicated that the skills are to some degree perceived as interlinked. Specifically, the communication and leadership skills seem to have overarching functions. Through the presentation of the skills, we have seen that interpersonal aspects are of particular salience—also for the skills normally considered to be mainly cognitive. During debriefings, these are often primarily explained as intrapersonal phenomena. As discussed further in the Limitations section, although these results may be taken into account of the specific salience of the interpersonal aspects of these skills, there are aspects in the training setting that also may have affected these results. In the following, we will discuss the results of the study in light of existing theory.

### 4.1 Situation awareness

The first theme for discussion is situation awareness. Endsley's (1995) model is one of the most cited situation awareness models. It includes three levels: *perception*,

*comprehension*, and *projection*. Elements of this model are reflected in our results, although the informants do not themselves use the division of levels presented by Endsley.

In relative concurrence with the first level, the informants highlight the importance of taking in information from their surroundings. They understand *general scanning* and *targeted information gathering* as two complementary strategies for information gathering that they actively engage in. This finding indicates that operators' understanding of situation awareness includes both data-driven information gathering *and* a targeted top-down strategy, where understanding of the situation and projections of future events spur the search for specific information. This notion supports existing theory, as Endsley (2015) points out that the model includes a notion that human information processing in complex systems (such as the ship's bridge) must be seen as a dynamic and complementary process that includes both bottom-up and top-down processing.

Although it is part of Endsley's model, informants are not found to focus on the understanding of situational cues (level 2). Rightfully, it can be claimed that what Endsley labels level 2 lies *implicit* in their understanding. For example, one could claim that *targeted information gathering* must be spurred by preexisting *understanding of information*. Thus, the traditional level 2 could be understood as a prerequisite for a targeted information search. In that aspect, our results indicate that participants understand situation awareness as dynamic rather than linear: the current understanding of a situation directs both the information search and what information is considered salient. Thus, the results could be taken to support the theory indicating that people participate in building their own situation awareness. In the words of Endsley (2015, p. 6): "People are active participants in the development of their own situation awareness, based on how they direct their attention, communicate with team mates and manipulate their tools to search for desired information."

Admittedly, the debriefing session facilitators did not specifically probe the question of whether or not the informants *perceived* the division between levels. However, as mentioned, our results indicate that the informants do not make a separation between levels 1 and 2 or between 2 and 3 specifically. One possible explanation for this is the difficulty in *observing* cognitive effort (Flin et al. 2008). Given the cognitive properties of level 2, specifically, it is not necessarily possible nor meaningful for expert mariners themselves to *distinguish* between these three levels during performance or debriefing (Endsley 2015). We take our results as an argument for more research, in order to investigate whether this apparent lack of conscious separation between levels of situation awareness is replicated in the maritime setting.

Further, informants highlight the ability to anticipate potential situation developments. The results indicate that operating in a state of anticipation is preferred to having to put out fires as problems occur. Our informants include anticipation of future situations, being proactive, and identifying and preparing resources for use as part of situation awareness. This aspect is also identified as one of the major factors in performing successful operations by the recent study by Jonassen and Hollnagel (2019). Informants seem to include evaluations of workload and one's own ability to cope with this future workload, as well as identification and preparation of potential resources, in their understanding of situation awareness. This combination of one's own abilities and available resources indicates that the officers treat them as parallel aspects

of a general evaluation of future situations. This part of their understanding mirrors both Endsley's level 3 and the skill *workload management*, in which this preference for using anticipative strategies is reflected in studies such as that of Chauvin and Lardjane (2008). Situation awareness and workload management are often considered two different (although to some degree overlapping) skills (e.g., Fjeld et al. (2018)). This division is also found in STCW (IMO 2011). We propose further research into the extent to which bridge officers themselves view these aspects as parallel or separate.

Informants focus on the importance of adequate distribution of cognitive resources, incorporating a sense of *collectiveness* in their understanding of situation awareness. Understanding overview as something that can be distributed amongst team members includes a dynamic that allows individuals to momentarily focus on their task, at the expense of losing the complete overview. Although the informants themselves do not label the behavior as such, this understanding is close to the description of distributed situation awareness (DSA) (Salmon et al. 2010). The latter often incorporates a notion that each team member has a unique set of tasks and thus a separate and distinct need for information. Theories on DSA often include a notion that non-human and human actors are both parts of building situation awareness. Our informants, however, do not seem to include the non-human actors in their understanding, possibly due to their relative unfamiliarity with the specific equipment and technical tools offered on the simulation bridge. As discussed further elsewhere, we do take these results into account of the specific salience of interpersonal aspects of skills, including those skills that are usually considered 'cognitive', highlighting the importance of providing a focus on team effort during BRM training.

## 4.2 Decision-making

Two forms of decision-making seem to be salient to the bridge officers: one form based on rules and procedures and one analytical form, often including discussion amongst several team members.

During debriefings, decisions are often discussed in the light of existing procedures and regulations. Several of the informants draw on the positive aspects of following well-fitted procedures, and the importance of knowing the procedures is often highlighted. Procedures can offer a guide for action in complex and dangerous situations (which, rightfully, are relatively common during BRM simulations). The operators state that they evaluate how suitable the rules are to the situation and indicate that they could be willing to break the rules under specific circumstances: if they find that the consequences of following them are grave. According to Flin et al. (2008), *rule-based decision-making* is frequently used by novices to learn the ropes and is also considered useful for intermediates and experts, as it can contribute to making decisions consistently and rapidly. The salience of this decision-making form could be affected by the operators considering the simulator to be a foreign setting: the bridge officers are often relatively inexperienced with the specific operations performed during training and could be considered novices in that respect.

The second theme is an analytical form of decision-making, in which different options are generated and explored before a decision is made. Here too, do the informants have a specific focus on the interpersonal aspects of the skill. We find that observers praise participant teams that *discuss* matters before action is taken. Although

this perspective is relatively rarely seen in studies on bridge officers' NTS (Fjeld et al. 2018), it is in line with Bailey et al. (2006), who point to the conversation between bridge team members as a forum for collective decision-making.

The informants rarely touch upon naturalistic decision-making forms during debriefings, although these are normally believed to be of great importance in most operational settings (Flin et al. 2008). According to studies such as those of Klein (1993) and Klein (2008), naturalistic or recognition primed decision-making (NDM/RPD) is dependent on relevant previous experience. Thus, the unfamiliar BRM setting, and the fact that the content of scenarios is non-routine to most participants, may contribute to a more extended use for—and focus on—more rule-based and analytical decision forms.

Further, in the cases where RPD is used, it is probably not easy for participants and observers to recognize it as happens “in action,” as RPD is often considered to be based on largely unconscious cognitive processes. In fact, operators do not necessarily recognize that they are engaged in such forms of decision-making. Rather, they feel like they simply “meet the needs of the situation” (Klein 1993). This could make it challenging for the informants to discuss these aspects of decision-making during debriefing sessions. Certain efforts have been taken to explore training of naturalistic decision-making in a simulator setting (Chauvin et al. 2009); however, more research could shed light on the specific standing of training NDM in the—to many training participants—unfamiliar and, in some aspects artificial, BRM setting.

### 4.3 Stress management

Studies targeting stress at sea have focused on the negative effects of occupational stress on the health and well-being of seafarers and the effect acute stress has on performance and safety (Håvold 2015; Pawar et al. 2012). In the present study, maintaining a calm bridge is considered important. Participant bridge teams that manage to “maintain calm” are praised, and *whether* the bridge team handles stressful situations or not is frequently discussed. Embedded in this is an understanding that high levels of stress have a detrimental effect on the performance of both individuals and teams. This notion is supported by Flin et al. (2008), who indicate that it only takes one stressed team member to disturb key interpersonal skills, and that symptoms of stress at team level include failure of communication, teamwork, and decision-making. Further, the informants seem to view stress as contagious. This is known from other domains; for example, in their study of scrub nurses, Mitchell et al. (2011) identify that coping with stress is important, not only because stress hinders individual performance but because it is contagious. If one team member loses his/her head, detrimental stress can easily spread throughout the team.

Research from other domains indicates that it is challenging to eliminate the acute stressors from the operational setting. Thus, operators' *secondary prevention*—the “prompt detection and management of the symptoms and effects of stress”—is essential (Flin et al. 2008, p. 180). From other domains, training including cognitive and physiological control techniques and enhancing flexibility is known to be useful (Flin et al. 2008). For example, Chapin et al. (2008), p. 346 indicate that police officers are encouraged to use strategies that include self/team partner care, such as “Focus on the immediate operation,” “Take a deep breath, shrug shoulders to reduce tension” and “Make yourself look calm and in control”, to cope with stressful operations.



As discussed elsewhere, strategies for preventing and mitigating stress are considered a part of the leadership skill, in that the leader has a responsibility to model calm behavior and use tone of voice and orders to help the other team members remain calm. However, the informants do not discuss stress management at team-member level. In some respects, this could be claimed to mimic the findings of Fjeld et al. (2018), which indicate that few if any studies target the concrete or practical particularities of how bridge officers *manage* acute stress when they are in the situation. One interesting question for future research could be whether—and how—bridge team members consciously use displays of calmness or stress to affect one another during operations.

In the BRM training setting it is the acute stress reactions, and how well the bridge officers handle these, that gets most of the attention. However, although this not commonly included in the simulations of BRM training, long term or chronic forms of stress can also affect performance and well-being on board (Flin et al. 2008). These forms of stress may not be easily prevented or handled by the individual in the sharp end, as they stem from factors that is not easily controlled by the bridge officer such as loneliness from being away from family for long periods of time (Carotenuto et al. 2012) work-pressure and fatigue due to lack of sleep (Håvold 2015). It can be claimed that much of this stress could be prevented or mitigated if work on board was planned in a sustainable manner by those working in the blunt end of the system. One example of this could be making sure manning on board is sufficient for crew to perform tasks properly, another could be following shift plans where the crew may avoid sleep deprivation and debilitating fatigue. This highlights the shipping companies' role in preventing contributing prevention and mitigation of stress amongst crew.

#### 4.4 Communication

The informants understand communication to fulfill an overarching function. For example, they describe how communication plays a key role in analytical decision-making and how verbal cues from the leader can contribute to the team's stress management and coordination of team effort through orders. Further, verbal communication provides a manner of information transfer and thus contributes to building both individual and team situation awareness: pushing and gathering specific information, identifying and correcting misunderstandings. This overarching role is known from other domains. For example, Salas et al. (2005) describe communication as an overarching facilitator for team work. In various NTS taxonomies too, communication is often thought to be in a specific position of influence (Flin et al. 2008). In fact, while communication is included as a separate skill in some behavioral markers assessing NTS, such as the behavioral marker tool, Non-Technical Skills for Surgeons (NOTSS) (Yule et al. 2008), it is excluded from other tools. In the behavioral marker tool, Non-TECHNical Skills (NOTECHS), used to assess aviation pilots' NTS, communication is not included as a separate skill, as it is considered a medium through which the other skills are conveyed (Flin et al. 2003). Whether communication should be considered a separate NTS for bridge officers could be a matter of discussion for future research. Indicating that at least some part of communication might deserve a place in a taxonomy of bridge officers' NTS is our informants' understanding of the importance of the *form* of communication, relatively regardless of its function.

The quality of communication is of importance to the informants; they highlight that communication must be clear and unambiguous and delivered and received in a manner that is resilient to misunderstandings. Unsurprisingly, this is mirrored in several studies performed in the bridge team setting (Chauvin et al. 2013; Sandhåland et al. 2015). Further, the informants highlight the importance of responding properly to messages: using confirmatory form and asking whether the message is not received or understood properly. The use of such strategies to lower the chance of—and mitigate—misunderstandings is also well known from other studies (Bailey et al. 2006; Salas et al. 2005).

Further, communication internally on the bridge seems to be understood differently than communication performed with external actors (through radio communication). Specifically, informants' explanations indicate that communicating with externals can be more prone to misunderstandings, specifically when the information is complex. This notion is supported by studies such as those of Hutchins (1995) and Kataria et al. (2015). Hutchins (1995, p. 121) points to reasons why radio communication can be especially challenging when meeting unfamiliar or unanticipated circumstances:

The mandated language on the intercom is almost telegraphic. This is adequate when the desired communication and its contents are anticipated – when the possible messages have been spelled out and agreed upon in advance. However, it is difficult to negotiate a novel understanding of the nature of a problem or to jointly interpret a complex world on such a low-bandwidth channel.

It is commonly believed that frequent and relevant information updates are essential to bridge work (Øvergård Nielsen et al. 2015). This is reflected in the results of the present study. As mentioned, observers praise participants for communicating often and frequently, indicating that this is understood as a sign of a well-functioning team, ensuring information flow. However, there is also a notion that there is a balance between *enough* and *too much communication*. Some worry that “too much” has a danger of becoming a distraction, leading to confusion and increasing complexity rather than clarification. Although this has been the subject of research in other domains, to our knowledge, no studies have targeted the role of verbal communication in relation to information overload (Miller 1956) or interruptions (Coraggio 1990) in this setting. However, future research could cast more light on this issue.

The informants highlight the importance of all relevant team members participating in communication. Further, participants highlight assertiveness and the importance of speaking up when needed. Team members speaking up when something is wrong is found to be of specific importance in operational settings (Edmondson 2003; Kish-Gephart et al. 2009; Lyndon et al. 2012). However, our informants also comment that this is not always easy to do. Reasons for operators sometimes choosing to not speak up have been explored in previous research (Bienefeld and Grote 2014; Kish-Gephart et al. 2009); however, domain-specific insight on this subject is lacking.

As discussed elsewhere, inclusion of all team members is also identified as an important theme under analytical decision-making and in the leadership skill, which highlights the interrelatedness and network of skills.

## 4.5 Balanced leadership

According to our informants, task distribution should include a clearly communicated set of responsibilities and tasks, balanced with the flexibility to change these when needed. All team members must be updated on who has which tasks, rights and responsibilities at any given time. This aspect is also discussed by Bailey et al. (2006), who highlight the importance of clear communication on roles and task distribution (e.g., who has the control of the ship at any given time). According to our informants, the leader has an overarching responsibility to manage the team and the task, distributing resources and delegating the workload amongst the team members. This aspect is supported by research such as Jonassen and Hollnagel (2019), which identify the importance of maintaining clear role and task distribution; and distributing and delegating tasks amongst team members. Further, our findings indicate the importance of balancing each individual team member's effort, so that no one member is overloaded—including the leader him/herself. Informants' descriptions indicate how the leadership skill includes both maintaining an overview of the situation and the ability to zoom in on tasks performed by each individual team member when necessary. These latter aspects are reflected in studies performed on leadership redundancy (e.g., Johannessen et al. 2011) and the importance of back-up behavior in team work (Salas et al. 2005).

Further, our results indicate that the leadership skill includes a balancing act between the inclusion of team members and clear decisiveness. This could have to do with the operational setting in general, and the BRM setting in particular, which sometimes call for undisputable operational orders. At the same time, our informants are clear that it is vital that leaders invite team members' opinions and that they communicate that the input is valued.

Studies from other domains indicate that “speaking up” or sharing one's opinion is not always easy to do, particularly if team members fear negative consequences for doing so—or if they have experiences that could indicate that their input is ignored or not valued (Edmondson 1999). Further, if invited and encouraged by the leader, the threshold for contributing is thought to diminish, thus making it more likely that team members contribute instead of holding back (Edmondson 1999, 2003; Nembhard and Edmondson 2006). The encouragement of input may be particularly challenging (though important) in operational settings, where the need to make rapid decisions and give clear orders is paired with the time-consuming need to absorb the input from team members. Further, as discussed in Section 3.4.2, results indicate that bridge officers believe that there can be too much communication. Such notions could lead to team members holding back important information at the wrong time, due to *pro-social motives* (not wanting to distract the team with unnecessary communication) (Van Dyne et al. 2003). These aspects could contribute to the salience of leaders' *invitation* to input, possibly giving team members extra reassurance and cues to participate. These notions should be further explored, as they touch upon important aspects of team performance that have gone relatively unexplored in this setting.

One final point on leadership is the leader's ability to remain calm (or at least appear calm) in the face of challenges. As described in Section 3.3, all team members are praised for remaining calm. However, leadership includes the main responsibility for the stress *management* of the team. The results indicate that the leader facilitates stress

management through modeling calm behavior, reassuring the team verbally, e.g., through using a calm tone of voice, and through orders “to take their time.” The particular salience of the leader’s demeanor could have to do with the overarching and visible role of the leader. The contagiousness of other psychological phenomena (such as emotions), leader-worker in a larger degree than worker-leader, is well documented (Sy et al. 2005). Further highlighting the specific standing the leader has in managing the team’s stress, O’Connor and Long (2011, p. 1385) describe “retaining a calm demeanor when under pressure and demonstrating to the watch that one is under control” as an essential *leadership skill* aspect.

As mentioned previously, to our knowledge, most of the research on stress in the maritime setting concerns the effects of stress and not the particularities of how bridge teams deal with stress in the operational setting. Thus, a further exploration of how leaders are perceived as active agents in affecting the team’s stress levels is encouraged.

#### 4.6 Potential limitations of research setting and research design

As the data were gathered in 2014, it could be claimed that the position of BRM may have changed since this. However, although the interest in Non-Technical skills is definitely rising (as evidenced by OCIMF/INTERTANKO 2018), there is little evidence to suggest that BRM training in Norway has changed considerably since the last wave of BRM training connected to the 2010 Manila amendment (IMO 2011). The data used in this study were sampled towards the end of that wave. Furthermore, there is little research on Non-technical skills in the maritime domain to feed such changes, as suggested by Fjeld et al. (2018).

The simulations that form the background for the debriefing sessions were a part of an approved BRM-training program. The scenarios were developed by a multi-disciplinary team (containing experienced bridge officers, simulation instructors, and researchers in the field), in a manner that supported potential discussion on a variety of subjects related to NTS. However, no set of simulations can cover the entirety of aspects of operations and situations. As they served as a common focus point for the debriefing setting, there is no doubt that the scenarios themselves have affected which skills and skill contents were of particular salience to the participants. For example, the content of the scenarios (crisis and SAR) and thus the discussion topics of the debriefing sessions may have been biased towards handling the unforeseen, rather than handling day-to-day operations.

BRM training is expected to target bridge officers of any sub domain of the maritime industry. Thus, the training course accessed was intended for bridge officers from a variety of backgrounds and competencies. Although the backdrop of the simulations (bridge layout, vessel type, type of operation, etc.) was built so that it did not require detailed task-specific technical knowledge unavailable to most bridge officers, it could be claimed that the related tasks could be considered unfamiliar for many of the informants. In relation to the present study, some even indicated that the simulations felt foreign and far from their daily tasks, with the respect to type of operation, etc. This could have affected the behavior of both participants’ and observers’ understanding of what was going on. However, experience with crisis- and SAR operations themselves is so sparse amongst BRM training participants that they are per definition non-routine to the point of feeling foreign.

Further, as the data gathering was performed in a training setting, there is always the risk that informants were affected by what they thought the group facilitator/interviewer wanted them to answer (Rosenthal and Fode 1963). However, in this particular setting, there is little to suggest that the facilitators exerted a stronger social pressure on the participants than the presence of the other participants. In the typical debriefing session, the facilitators were outnumbered two to 12, by experts with considerable professional experience. Also, the researchers were clear in their role and in what the group facilitation entailed, during the debriefing sessions.

Another aspect that could have affected the informants during debriefing sessions is the broad categories provided for observation during simulations. Although presented as mere suggestions, they could have primed informants to focus their attention on certain aspects, prompting them to ignore others (Katz 1942). On the other hand, an equally salient challenge is the informants' lack of common language to discuss aspects of relevance during simulations. Thus, although a certain framing could be claimed to color the object of observation, without a framing there is no object.

As all scenarios ran twice with informants taking turns observing and performing, there is the chance that phenomena such as learning effects may have affected them. However, as mentioned previously, the scenarios repetitions, although based on the same basic scripts, often turned out quite different—as the degree of freedom in behavior and potential actions was substantial. Rightfully, should learning effects occur despite these variations, this would have been detrimental to the study if this was a quantitative experiment study targeting aspects such as performance. However, the present study focuses on a qualitative exploration of the content of debriefing discussion and is thus not necessarily affected in a detrimental manner. In fact, it is the researchers experience that the repetition of scenarios seemed to help informants to explore different aspects in the range of behaviors and different scenario outcomes that occurred.

The highlighting of interpersonal and team aspects in both SA and decision-making could be reflections of the salience of the team in the real-world bridge setting as understood by the informants. However, it could also be affected by the BRM-training setting—where working together as a team is one of the main points. Rightfully, both cognitive and interpersonal aspects are important themes in the BRM training syllabus. However, the informants are aware that they are there to *demonstrate* skill knowledge and competence throughout the course. Much of this demonstration take the form of interaction and communication with other team members as they are easier to observe, compared to processes that mainly takes place inside the individuals head. Further, it could be that the informants, avoid talking about each individual's performance in order to protect each other from embarrassment, thus turning to the team aspect and collective effort to mask the individual's contribution (or, in some cases, lack thereof).

As previously mentioned, one informant indicated that discussion prior to decision-making may be especially relevant when bridge team members lack experience on a given aspect. The introduction of new tasks or equipment is quite common on normal ships' bridges. However, the BRM setting is characterized even more by unfamiliarity: team members, equipment, scenario content and even vessel type are often unknown to informants before training starts. Thus, this may well contribute to the apparent salience of discussing matters before making decisions. To explore these aspects further, more research should be performed into the role that group discussion plays during decision-

making on the bridge. If future studies conclude that these aspects are highlighted as a consequence of the training setting rather than a realistic reflection of bridge officers' NTS, this should be seen as an argument for more domain-specific tailored BRM training, more specialized to various parts of the domain, to better mimic realistic circumstances. For example, training should encompass scenarios that are specifically in line with the specific group of bridge officers' competencies (e.g., officers normally working on board tankers should train using simulations with content relevant to tanker vessels and tanking operations). Further, participants should be allowed to inhabit their usual role (e.g., "captain")—rather than having to adopt unfamiliar bridge team roles during training. These simple interventions could increase the sociological fidelity of the simulation training, known to be especially important when simulation training output is cognitive, interpersonal or team related (Sharma et al. 2011).

Finally, the current study aims to explore the understanding of NTS in bridge officers undergoing BRM training. The study, however, focuses on this particular setting and does not take into account the variation in the content of various existing BRM-training courses. Aspects that can be expected to vary between course providers—such as the narrative content of simulations, lectures on non-technical skills and so on—could have shaped the discussion to some degree. However, taking on all these aspects would represent an unwieldy data set for qualitative analysis. Neither was the aim of the study to compare different BRM-training courses. Ultimately such challenges are more realistically met by the research field accumulating multiple studies in a cumulative endeavor.

#### 4.7 Concluding thoughts

The present study identified five global themes, each corresponding to an established NTS skill in generic NTS literature: *situation awareness*, *decision-making*, *stress management*, *verbal communication* and *balanced leadership*. Mostly, the skills were found to be in concurrence with theory on non-technical skills. However, the results indicate that the bridge officers included in this study incorporate their own understanding of the BRM syllabus.

The informants do not focus specifically on the three levels of SA defined by theory. Instead, they focus on two practical strategies for building and maintaining overview: general lookout and targeted information gathering. These strategies are related to a second theme of distributing attention resources throughout the team. This allows individual team members to concentrate fully on a task (such as navigation in ECDIS, or maneuvering), while overview is still maintained elsewhere in the team. The salience of resources is also clear in the informants' discussions of proactivity. Future situations are not only anticipated in terms of risk and threat but in terms of workload and own capability. Future workload pressure is then managed by either cognitive or practical preparation or by early mobilizing of resources outside the bridge team. Implications: This highlights the importance of BRM training providing training participants with a strong connection between theory and practice. This should be done in a manner that both provides a strong theoretical fundament, while at the same time manages to contextualize the theory in action-oriented and recognizable terms, such as targeting the training participants' preoccupation with workload management.

Through the analysis, two forms of *DM* were identified. A procedure-based form and an analytical form. More naturalistic decision-making forms are not the subject of discussion in the present data. The informants focus on positive aspects of well-fitting procedures, and the importance of knowing these - as they can help organize a chaotic situation, and thus free up cognitive resources needed to handle other aspects of a critical situation. Further, the use of analytical decision-making and discussion in the team before a decision is made by the leader, is of salience to the informants. While recognizing that this may be a time-consuming effort, acquiring other team members' opinion on how to solve a problem is particularly useful when the situation is unfamiliar or one lacks experience. Implications: In addition to incorporating the forms of decision-making discussed by our informants, BRM training should ensure that also NDM is treated in a way that facilitates reflection on these decision-making processes. This could be done through providing scenarios where NDM is salient- and also through making sure that training introduce a conceptual framework and language that allows training participants to discuss NDM processes.

Our informants treat stress management exclusively as the skill to project calmness both as a means to avoid confusion, thus protecting own cognitive performance and as a means to avoid infectious spreading of stress on the bridge. The focus is particularly on the leader to maintain a calm bridge. Neither internal stress management nor signaling overload, soliciting support—two key aspects of stress management theory—are part of the discussions. Implication: BRM training needs to address techniques addressing own stress and come to terms with recommendable practice on how overload can be signaled without undermining a calm bridge.

In line with both research and maritime procedures, clear, precise, and unambiguous *communication* is understood to be resilient to misunderstandings. The informants also indicated that communication with external actors may be even more vulnerable to misunderstandings than intra team communication, and that extra care should be taken in order to make sure external messages is sent and received in a clear manner. The informants highlight that all team-members' must contribute and speak up when necessary. Furthermore, frequent and timely communication is encouraged. In contrast to this, there is also a sense that 'too much' communication could become distracting and lead to operator overload. This is considered a fine line that may be hard to distinguish for the informants. Implication: It is important that BRM training continue to provide opportunity to practice communicating in an assertive, frequent, clear and concise manner taking into consideration communication channel and the recipients' understanding and mental capacity.

Concerning *leadership*, the informants highlight the organizing aspect of clearly communicating tasks and responsibilities, balanced with the flexibility to change these when needed. Another highlighted aspect is Balanced authority which is understood as the ability to balance between the clear giving of undisputable orders and being inclusive and inviting team members to participate and give input. This skill aspect can thus be seen as related to the perceived importance of all team members' active participation in communication - where the leader is understood to have a specific responsibility to invite such input. At the same time, the leader has the final and undisputable decision power, and thus the responsibility to "put the foot down" when needed. Further, other parts of the

leadership skill overlaps/overarches with elements from other skills such as SA and stress management. Implications: The specific responsibilities put on the leader indicate that a bridge leader's visibility and impact on team performance through organization of tasks and resources is just as strong as it is in any other organizational/operational setting. It remains important that BRM training includes a specific focus on these aspects, and thus aid bridge leaders in recognizing their impact, and focus on how these leadership skill elements can be used to improve team performance. As exemplified several times throughout the text, our thematic network analysis uncovered certain interlinkages between skills, where certain skills seem to serve an *overarching function*. This aspect is mentioned in NTS literature (Such as Flin et al. 2008), though the details of how skills are interlinked in the maritime setting is not yet well known (Fjeld et al. 2018). As described above, the leadership skill is one that is considered linked closely to other skills, through the leaders' 'specific responsibility to i.e. maintain a calm bridge. Further, communication is also linked to the other NTS by the informants. Although it is highlighted that the manner of communication is important in its own right, it is also the skill that allows the team to 'execute' other NTS-related behavior on the bridge (such as discussion in the analytical decision-making). Communication is a visible manner through which other NTS can be observed (i.e. in the BRM training setting). To the extent that BRM training manages to present discrete skills with defined interlinkages, the training may be able to conceptually unpack what may otherwise appear to course participants as a tangle of woolly skills. This endeavor is likely to be facilitated by further progress in research targeting these linkages in the maritime domain.

Thus, future research could contribute to a more thorough exploration of each of the NTS and the overlap between skills—and how to better understand the overarching roles of leadership and communication skills. On a more general note, we also propose that future studies could include a similar set-up as the present study, although using (1) a wider variety of simulations and scenarios including more routine events, (2) alternative templates for discussion of varying degrees of structure, (3) scenarios more tailored to specific groups of informants, and (4) quantitative studies exploring the generalizability of the findings across various settings.

**Acknowledgments** The Research Council of Norway and companies in the maritime and offshore industries in Norway have funded the RISKOP Project (Managing Risk in Offshore Operations (grant no. 225311/070)). The project is based at the Western Norway University of Applied Sciences (previously Stord Haugesund University College) and is a collaboration with SINTEF and Uni Research Polytec.

**Funding information** Open Access funding provided by Western Norway University Of Applied Sciences.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.



## References

- Bailey N, Housley W, Belcher P (2006) Navigation, interaction and bridge team work. *Sociol Rev* 54(2):342–362. <https://doi.org/10.1111/j.1467-954X.2006.00617.x>
- Barnett M, Gatfield D, Pekcan C (2006) Non-technical skills: the vital ingredient in world maritime technology? Paper presented at the International Conference on World Maritime Technology. Institute of Marine Engineering, Science and Technology, London
- Bienefeld N, Grote G (2014) Speaking up in ad hoc multiteam systems: individual-level effects of psychological safety, status, and leadership within and across teams. *Eur J Work Organ Psy* 23(6):930–945. <https://doi.org/10.1080/1359432X.2013.808398>
- Braun V, Clarke V (2006) Using thematic analysis in psychology. *Qual Res Psychol* 3(2):77–101. <https://doi.org/10.1191/1478088706qp0630a>
- Braun V, Clarke V, Terry G (2014) Thematic analysis. *Qual Res Clin Health Psychol*: 95–114. Retrieved from <http://www.apa.org/pubs/books/4311505.aspx>
- Carotenuto A, Molino I, Fasanaro AM, Amenta F (2012) Psychological stress in seafarers: a review. *Int Marit Health* 63:188–194
- Chapin M, Branne SJ, Singer MI, Walker M (2008) Training police leadership to recognize and address operational stress. *Police Q* 11(3):338–352. <https://doi.org/10.1177/1098611107307736>
- Chauvin C, Lardjane S (2008) Decision making and strategies in an interaction situation: collision avoidance at sea. *Transp Res F-Traf* 11(4):259–269. <https://doi.org/10.1016/j.trf.2008.01.001>
- Chauvin C, Clostermann J-P, Hoc JM (2009) Impact of training programs on decision-making and situation awareness of trainee watch officers. *Saf Sci* 47(9):1222–1231. <https://doi.org/10.1016/j.ssci.2009.03.008>
- Chauvin C, Lardjane S, Morel G, Clostermann J-P, Langard B (2013) Human and organisational factors in maritime accidents: analysis of collisions at sea using the HFACS. *Accid Anal Prev* 59:26–37. <https://doi.org/10.1016/j.aap.2013.05.006>
- Conceição V, Basso J, Lopes C, Dahlman J (2017) Development of a behavioural marker system for rating cadet's non-technical skills. *TransNav* 11. <https://doi.org/10.12716/1001.11.02.07>
- Coraggio L (1990) Deleterious effects of intermittent interruptions on the task performance of knowledge workers: a laboratory investigation. Doctoral dissertation, University of Arizona
- Dakic J, Milinic D, Tripovic S (2014) BRM training. *The Navigator* 7:5
- Edmondson (1999) Psychological safety and learning behavior in work teams. *Adm Sci Q* 44(2):350–383. <https://doi.org/10.2307/2666999>
- Edmondson (2003) Speaking up in the operating room: how team leaders promote learning in interdisciplinary action teams. *J Manag Stud* 40(6):1419–1452. <https://doi.org/10.1111/1467-6486.00386>
- Endsley MR (1995) Toward a theory of situation awareness in dynamic systems. *Hum Factors* 37(1):32–64. <https://doi.org/10.1518/001872095779049543>
- Endsley MR (2015) Situation awareness misconceptions and misunderstandings. *J Cogn Eng Decis Mak* 9(1): 4–32. <https://doi.org/10.1177/1555343415572631>
- Fanning RM, Gaba DM (2007) The role of debriefing in simulation-based learning. *Simul Healthc* 2(2):115–125. <https://doi.org/10.1097/SIH.0b013e3180315539>
- Fjeld GP, Tvedt SD, Oltedal HA (2018) Bridge officers' non-technical skills: a literature review. *WMU J Marit Aff* 17:475–495. <https://doi.org/10.1007/s13437-018-0158->
- Flin R, Martin L, Goeters K-M, Hormann H, Amalberti R, Valot C, Nijhuis H (2003) Development of the NOTECHS (non-technical skills) system for assessing pilots' CRM skills. *Hum Factors Aerosp Saf* 3:97–120
- Flin R, O'Connor P, Crichton M (2008) *Safety at the sharp end: a guide to non-technical skills*. Ashgate, Surrey
- Gordon M, Darbyshire D, Baker P (2012) Non-technical skills training to enhance patient safety: a systematic review. *Med Educ* 46(11):1042–1054. <https://doi.org/10.1111/j.1365-2923.2012.04343.x>
- Håvold JI (2015) Stress on the bridge of offshore vessels: examples from the North Sea. *Saf Sci* 71:160–166. <https://doi.org/10.1016/j.ssci.2014.03.009>
- Hetherington C, Flin R, Mearns K (2006) Safety in shipping: the human element. *J Saf Res* 37(4):401–411. <https://doi.org/10.1016/j.jsr.2006.04.007>
- Hutchins E (1995) *Cognition in the wild*. MIT Press, London
- International Maritime Organization (IMO) (2011) *STCW Convention and STCW Code*. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers. Including the 2010 Manila Amendments. International Maritime Organization, London

- Johannessen IA, McArthur PW, Jonassen JR (2011) Leadership redundancy in a multiteam system. In: Frick J, Laugen BT (eds) *Advances in production management systems. Value networks: innovation, technologies, and management*. APMS 2011. IFIP Advances in information and communication technology, vol 384. Springer, Berlin, Heidelberg
- Jonassen JR, Hollnagel E (2019) License to intervene: the role of team adaptation in balancing structure and flexibility in offshore operations. *WMU J Marit Aff* 18:103–128. <https://doi.org/10.1007/s13437-019-00166-y>
- Kataria A, Holder E, Praetorius G, Baldauf M, Schröder-Hinrichs J-U (2015) Exploring bridge-engine control room collaborative team communication. *Trans Nav* 9(2). <https://doi.org/10.12716/1001.09.02.02>
- Katz D (1942) Do interviewers bias poll results? *Public Opin Q* 6(2):248–268. <https://doi.org/10.1086/265548>
- Kish-Gephart JJ, Detert JR, Treviño LK, Edmondson AC (2009) Silenced by fear: the nature, sources, and consequences of fear at work. *Res Organ Behav* 29:163–193. <https://doi.org/10.1016/j.riob.2009.07.002>
- Klein G (1993) *A recognition-primed decision (RPD) model of rapid decision making*. Ablex Publishing Corporation, New York
- Klein G (2008) Naturalistic decision making. *Hum Factors* 50(3):456–460. <https://doi.org/10.1518/001872008x288385>
- Lyndon A, Sexton JB, Simpson KR, Rosenstein A, Lee KA, Wachter RM (2012) Predictors of likelihood of speaking up about safety concerns in labour and delivery. *BMJ Qual Saf* 21(9):791–799. <https://doi.org/10.1136/bmjqs-2010-050211>
- Miller GA (1956) The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychol Rev* 101(2):343–352. <https://doi.org/10.1037/0033-295X.101.2.343>
- Mitchell L, Flin R, Yule S, Mitchell J, Coultts K, Youngson G (2011) Thinking ahead of the surgeon. An interview study to identify scrub nurses' non-technical skills. *Int J Nurs Stud* 48(7):818–828. <https://doi.org/10.1016/j.ijnurstu.2010.11.005>
- Nembhard IM, Edmondson AC (2006) Making it safe: the effects of leader inclusiveness and professional status on psychological safety and improvement efforts in health care teams. *J Organ Behav* 27(7):941–966. <https://doi.org/10.1002/job.413>
- O'Connor P, Long WM (2011) The development of a prototype behavioral marker system for US Navy officers of the deck. *Saf Sci* 49(10):1381–1387. <https://doi.org/10.1016/j.ssci.2011.05.009>
- O'Connor P (2011) Assessing the effectiveness of bridge resource management training. *Int J Aviat Psychol* 21(4):357–374. <https://doi.org/10.1080/10508414.2011.606755>
- Oil Companies International Marine Forum (OCIMF) & INTERTANKO (2018) *Behavioural competency assessment and verification for vessel operators*. www.ocimf.org, London
- Øvergård Nielsen AR, Nazir S, Sorensen LJ (2015) Assessing navigational teamwork through the situational correctness and relevance of communication. *Procedia Manuf* 3:2589–2596. <https://doi.org/10.1016/j.promfg.2015.07.579>
- Pawar A, Chikkanna C, Rote M, Sing R, Bhano G, Pillai A, Pisharody R (2012) Occupational stress and social support in naval personnel. *Med J Armed Forces India* 68(4):360–365. <https://doi.org/10.1016/j.mjafi.2012.04.026>
- Rosenthal R, Fode KL (1963) The effect of experimenter bias on the performance of the albino rat. *Behav Sci* 8(3):183–189
- Saeed F, Wall A, Roberts C, Riahi R, Bury A (2017) A proposed quantitative methodology for the evaluation of the effectiveness of human element, leadership and management (HELM) training in the UK. *WMU J Marit Aff* 16:115–138. <https://doi.org/10.1007/s13437-016-0107-7>
- Salas E, Fowlkes JE, Stout RJ, Milanovich DM, Prince C (1999) Does CRM training improve teamwork skills in the cockpit?: two evaluation studies. *Hum Factors* 41(2):326–343. <https://doi.org/10.1518/001872099779591169>
- Salas E, Sims DE, Burke CS (2005) Is there a “big five” in teamwork? *Small Group Res* 36(5):555–599. <https://doi.org/10.1177/1046496405277134>
- Salmon PM, Stanton NA, Walker GH, Jenkins DP, Rafferty L (2010) Is it really better to share? Distributed situation awareness and its implications for collaborative system design. *Theor Issues Ergon Sci* 11(1–2): 58–83. <https://doi.org/10.1080/14639220903009953>
- Sandhåland H, Oltedal H, Eid J (2015) Situation awareness in bridge operations – a study of collisions between attendant vessels and offshore facilities in the North Sea. *Saf Sci* 79:277–285. <https://doi.org/10.1016/j.ssci.2015.06.021>
- Sellberg C (2017) Simulators in bridge operations training and assessment: a systematic review and qualitative synthesis. *WMU J Marit Aff* 16:247–263. <https://doi.org/10.1007/s13437-016-0114-8>
- Sharma S, Boet S, Kitto S, Reeves S (2011) Interprofessional simulated learning: the need for sociological fidelity. *J Interprofessional Care* 25(2):81–83. <https://doi.org/10.3109/13561820.2011.556514>

- Shinnick MA, Woo M, Horwich TB, Steadman R (2011) Debriefing: the most important component in simulation? *Clin Simul Nurs* 7(3):e105–e111. <https://doi.org/10.1016/j.ecns.2010.11.005>
- Sy T, Côté S, Saavedra R (2005) The contagious leader: impact of the leader's mood on the mood of group members, group affective tone, and group processes. *J Appl Psychol* 90(2):295
- Tvedt SD (2019) Teamtrening i maritime simulatorer. [Team training in maritime simulators.]. In: Johnsen BH, Eid J (eds) *Operativ Psykologi II: anvendte aspekter*. Fagbokforlaget, Bergen
- Uramatsu M, Fujisawa Y, Mizuno S, Souma T, Komatsubara A, Miki T (2017) Do failures in non-technical skills contribute to fatal medical accidents in Japan? A review of the 2010–2013 national accident reports. *BMJ Open* 7(2):e013678. <https://doi.org/10.1136/bmjopen-2016-013678>
- Van Dyne L, Ang S, Botero IC (2003) Conceptualizing employee silence and employee voice as multidimensional constructs. *J Manag Stud* 40(6):1359–1392. <https://doi.org/10.1111/1467-6486.00384>
- Wahl AM, Kongsvik T (2018) Crew resource management training in the maritime industry: a literature review. *WMU J Marit Aff* 17:377–396. <https://doi.org/10.1007/s13437-018-0150-7>
- Yule S, Flin R, Maran N, Rowley D, Youngson G, Paterson-Brown S (2008) Surgeons' non-technical skills in the operating room: reliability testing of the NOTSS behavior rating system. *World J Surg* 32(4):548–556. <https://doi.org/10.1007/s00268-007-9320-z>

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.