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Human Error in Pilotage Operations

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ABSTRACT: Pilotage operations require close interaction between human and machines. This complex sociotechnical system is necessary to safely and efficiently maneuver a vessel in constrained waters. A sociotechnical system consists of interdependent human- and technical variables that continuously must work together to be successful. This complexity is prone to errors, and statistics show that most these errors in the maritime domain are due to human components in the system (80 – 85%). This explains the attention on research to reduce human errors. The current study deployed a systematic human error reduction and prediction approach (SHERPA) to shed light on error types and error remedies apparent in pilotage operations. Data was collected using interviews and observation. Hierarchical task analysis was performed and 55 tasks were analyzed using SHERPA. Findings suggests that communication and action omission errors are most prone to human errors in pilotage operations. Practical and theoretical implications of the results are discussed.

1 INTRODUCTION

The maritime industry constantly performs challenging operations with much potential for human errors. These operations need a delicate interplay between human and technological factors organized in a sociotechnical system to achieve complex goals: e.g. to successfully transport hazardous cargo in constrained and shallow waters alongside heavy traffic. Sociotechnical systems are characterized by high numbers of dynamic and interdependent tasks that are necessary to successfully perform a wide range of complex operations. All components of these systems must work separately and in mutual dependency with each other. In the maritime domain, technical errors are less prone than human errors, which dictates the amplitude necessary to put on training and assessment of operator's error performance.

Human error happens all time and is an inevitable part of human nature. Within the maritime industry; however, human errors generate critical consequences so severe they are worth spending time and resources to prevent and mitigate (Kim and Nazir 2016). Such consequences are associated with costly damages to equipment, loss of lives, severe injuries, or environmental pollution.

Human error is involved in between 80-85 % of maritime accidents (Hanzu-Pazara et al. 2008). Consequently, much resources are spent to improve human performance and reduce human error.

Error and human reliability have been researched from multiple perspectives, i.e. preventive or reactive, and levels i.e. an individual-, team-, and all the way to the organizational- or societal level. This is necessary considering that human performance is influenced on all levels of analysis, from individual cognitive patterns to organizational structure.

Ultimately, it requires strenuous efforts to pinpoint when and where errors are likely to happen. The type of errors and probability of human error to occur can be found through careful analysis of tasks and system requirements. This will yield designers and trainers information of which specific tasks and system characteristics need fortification. This proactive approach to human error is valuable for the maritime industry (with much competition and scarce resources) considering the cost of consequences, despite the efforts needed to implement measures against human errors.

Experts and novices are both prone to errors. Experience is an essential part of expertise, and the road to become an expert involves developing mental schemas. The schemas help the operator by reducing the time taken to recognize situations and to make decisions and corrective actions accordingly (Nazir et al. 2013). Experts have sophisticated ways to subconsciously know what to do – often characterized by experts telling that “they just know”. Their schemas allow them to understand situations triggered by small, subtle cues within the environment. As opposed to experts, novices have mental schemas that are less effective, thus relying on more attention and cognitive resources to perceive, understand, and predict the same situation. This difference manifests in the antecedents related to the errors conducted in complicated situations: Where experts can perceive subtle environmental cues to understand the situation while monitoring, novices must pay closer attention to catch the same cues. Experts; who uses less attention and rely on mental patterns, can be misguided when perceiving or interpreting environmental cues, consequentially making a poor decision and action. Novices are less likely to make the same mistake as they pay more resources to the environment and interprets the cues more consciously, but this makes novices more prone to overload, which therefore, makes them ignorant to important environmental cues about the situation. In complex maritime operations, understanding these characteristics are of paramount importance to effectively implement measures that reduce the probability and mitigate consequences of human errors.

Pilotage is a renown complicated pilotage operation (Sharma and Nazir 2017). Considering the dynamic nature of pilotage operations, i.e. that the safest situation often is to keep going, puts pressure to continuously maintain situation awareness. Loss of it, by for instance the mechanisms depicted above, may result in an accident. There are many examples of accidents during pilotage operations, e.g. Godafoss, Federal Kivalina and Crete Cement accidents (Accident Investigation Board 2010a; Accident Investigation Board 2010b; Accident Investigation Board 2012). To assess human reliability in an operation, one must understand the operation itself. Thus, next a depiction of a generic pilotage operation.

Pilotage operations can be broken down to eight main tasks: Order and get the pilot aboard, develop group relationship, installing the pilot, assess environment and weather, decide route, supervise navigation, coordinate tugboats and berthing (Ernstsen et al. In Press). Developing group relationship and assessing environment and weather are non-sequential continuous tasks, while the other tasks are usually performed in the sequence shown in Figure 1 below.

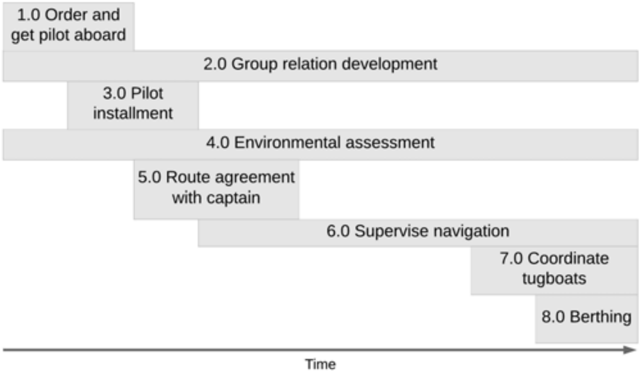


Figure 1. Timeline of tasks in pilotage operation

Pilotage operations are dynamic with many interdependent tasks. It also consists of much subtle and non-transparent feedback from the system, making it more challenging and mentally intensive to perceive, assess, understand, and decide the proper course of action. For instance, radar with unprecise settings may detect noise which can be both waves or fishing vessels to an untrained eye. Thus, operators in pilotage operations are heavily dependent on individual skills and knowledge of the operation, as well as efficient collaboration to successfully bring the vessel to berth or out of the port. This complexity gives much potential to do human errors, which emphasizes the need to understand the nature of such errors.

Human error research vastly increased after complex accidents in the 70s and 80s, e.g. Three-Mile Island and Chernobyl. The focus changed from technical malfunctions to acknowledging the role of human factors. After this, accident investigations began to look for errors caused by human components, either it being found at the sharp- or the blunt end. Error research became popular, and as a consequent, many theories were developed according to how it is conceptually applied, e.g Rasmussen (1983); Reason (1990); Sanders and Moray (1991); Wickens et al. (2015); Woods et al. (1994).

Hollnagel (2000) attempted a novel view of error, looking at errors as contextual factors influencing (normal) performance variability and dictates one need to understand how these factors influence behavior to understand how situational changes impact performance variability (as opposed to coin it “human error”). As mentioned, pilotage operations are complex, dynamic with a multitude of interdependent tasks. This dictates a need to understand which environmental circumstances affects human reliability to allow pinpointed training and design alterations.

Human reliability is the positive orientation of human error. Human reliability assessment (HRA) is a broad name for ways to find and predict human errors in a system. The increase in human error research have resulted in a high number of various human reliability assessment methods, and most can be divided as quantitative or qualitative approaches to understand and predict human error. For instance, Bell and Holroyd (2009) found 72 tools related to human reliability. Please see Aalipour et al. (2016) for a short review of more HRA examples. The basic functions of most HRA methods are: (1) to find human errors associate with the operation, (2) predict the likelihood of occurrence, and (3); if necessary, reduction of their likelihood (Park and Jung 1996). Quantitative approaches to human error are mostly concerned with human error probabilities, which, according to Bell and Holroyd (2009), is defined as depicted in Equation 1:

$$P(HE) = \frac{N_E}{N_{EO}} \tag{1}$$

where N_E is number of errors and N_{EO} is number of opportunities for errors. However, to find data to calculate error probability is challenging and often due to much subjectivity. A countermeasure is to first thoroughly understand which error types are prone to occur in the operation under analysis before attempting to calculate error probabilities.

The complexity of HRA increases as the operation is more intertwined in a sociotechnical framework as there are more interdependent and dynamic variables influencing the human reliability. This makes it even more difficult to thoroughly understand which error types exists. To find them in a complex system; however, SHERPA is a suitable human reliability assessment method for maritime operations.

The main contribution of the current paper is to perform SHERPA to identify error types for the eight tasks associated with a pilotage operation, as mentioned above. A SHERPA can shed novel light on complex operations through a consistent analysis of tasks, error types and potential consequences associated with tasks. The goal is to provide information about human errors in pilotage operations.

2 METHOD

Data was collected using interview and observation. The interviews were unstructured, open-ended interviews and observations. The interview was designed to gather information regarding tasks and goals associated to a pilotage operation and the cognitive demands for the pilots and captain respectively. The interviewees were presented with a scenario of a 30.000 dead-weight oil tanker with a goal to berth at Slagentangen oil refinery in Norway. It is a standard scenario that most captains and pilots have experienced or at least can relate to. A definition of a medium sized accident was inquired mid of the scenario talk-through. The participants were asked to rank the accident to a level 4 on a 10-level scale, with level 10 being the accident with highest consequences, e.g. explosion and loss of life or severe casualties.

All interviews began with a review of informed consent to participate and to audio record the interviews. The length was 1 hour and 15 minutes on average, longest 1 hour and 37 minutes and shortest 1 hour and 5 minutes. When data saturation was achieved, a shift towards validation of data occurred to ensure a valid representation of the piloting operation. The same interviewer was used to ensure consistency. Data collection process and storing was approved by Norwegian Centre for Research Data.

Observation was issued to collect data and to validate and verify findings following the task analysis. The observation scenario was to follow a pilot on a car cargo vessel leaving Oslo Port bound to Hvasser pilot station. The researcher was conscious to notice the occurrence of tasks that were identified from the interview data. The observation was open, and the researcher could ask question throughout the voyage to ensure a consistent and elaborate understanding of the operation.

2.1 *Sampling and response rate*

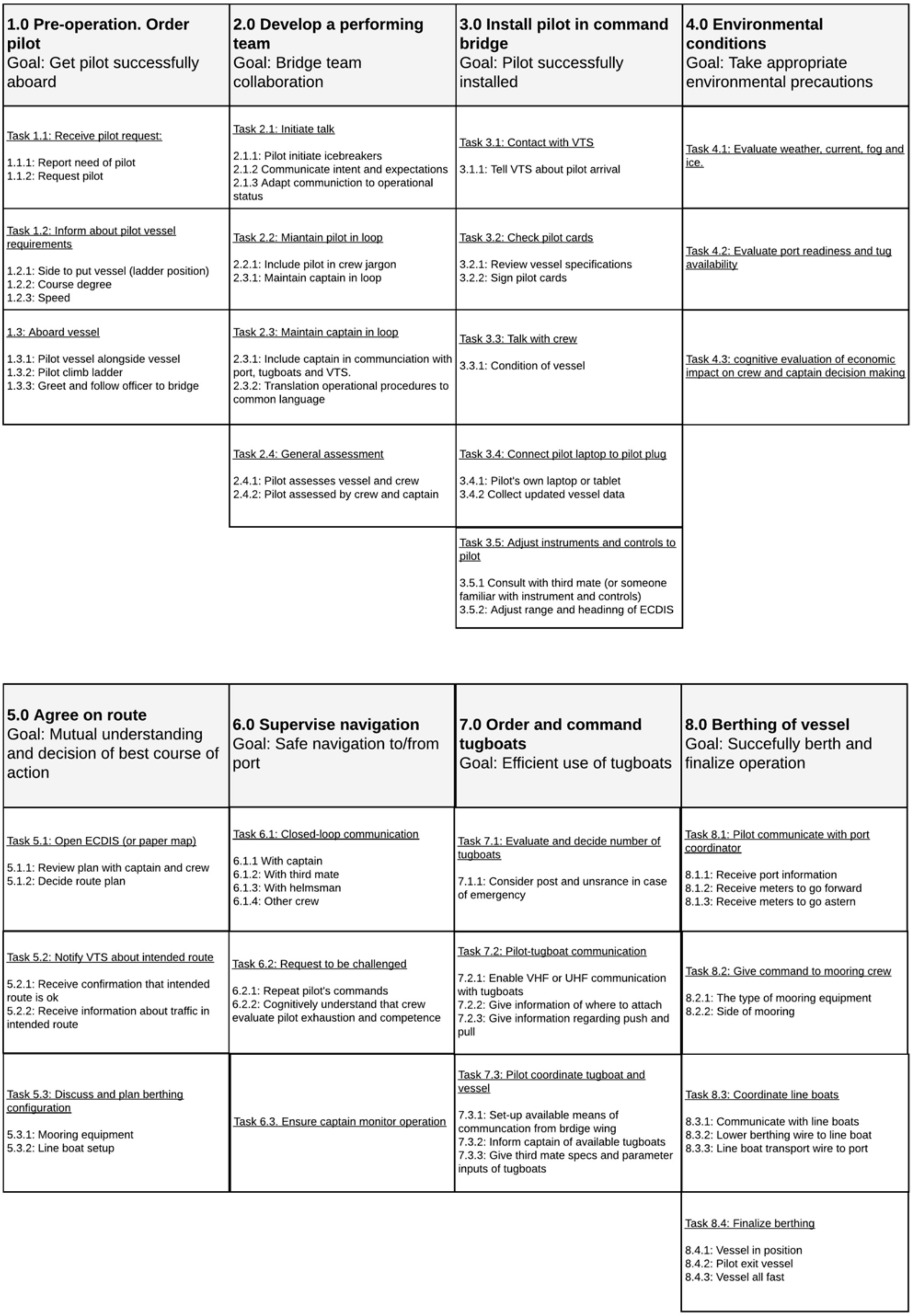
The snowball-approach was used to gather interviewees (i.e. ask interviewees to provide colleague/friends fitting the criteria of interviewee). Eight interviewees with piloting expertise contributed to the analysis and four interviewees with captain expertise. To be a captain or pilot requires much experience, thus all applicable interviewees were deemed subject matter experts considering their work positions. The interviews had slightly shift during the research, consistent with the iterative development of much qualitative research: the development and validation of the task analysis and further, validation of SHERPA. Most interviews were conducted in-person; however, due to geographical separation, three interviews were done using FaceTime®.

2.2 *Structure and analyze results*

Interview data were transcribed verbatim. More efficient transcription methods were used as data saturation approached, e.g. transcription of only relevant sections of dataset. Tasks and functions for the task analysis were identified with both a grounded (i.e. bottom-up) and a theoretical/practical evaluation (top-down), where the information is evaluated by subject matter experts.

2.2.1 *Content analysis and task analysis*

Content analysis is a common way to analyze textual data where the basic principle is to code data into categories. Categories can be grounded directly from the text itself or relate to established theories. The interview transcription was coded to converge tasks and goals revealed in the interviews. The record was broken down to be analyzed with the purpose of identifying emerging categories within the dataset. This was used to structure and provide input to the task analysis. Content analysis is a powerful way to reduce confirmation bias when understanding interview data. The information from the content analysis was used to structure the hierarchical task analysis.



1.0 Pre-operation. Order pilot Goal: Get pilot successfully aboard	**2.0 Develop a performing team** Goal: Bridge team collaboration	**3.0 Install pilot in command bridge** Goal: Pilot successfully installed	**4.0 Environmental conditions** Goal: Take appropriate environmental precautions
Task 1.1: Receive pilot request: 1.1.1: Report need of pilot 1.1.2: Request pilot	Task 2.1: Initiate talk 2.1.1: Pilot initiate icebreakers 2.1.2 Communicate intent and expectations 2.1.3 Adapt communiction to operational status	Task 3.1: Contact with VTS 3.1.1: Tell VTS about pilot arrival	Task 4.1: Evaluate weather, current, fog and ice.
Task 1.2: Inform about pilot vessel requirements 1.2.1: Side to put vessel (ladder position) 1.2.2: Course degree 1.2.3: Speed	Task 2.2: Miantain pilot in loop 2.2.1: Include pilot in crew jargon 2.3.1: Maintain captain in loop	Task 3.2: Check pilot cards 3.2.1: Review vessel specifications 3.2.2: Sign pilot cards	Task 4.2: Evaluate port readiness and tug availability
1.3: Aboard vessel 1.3.1: Pilot vessel alongside vessel 1.3.2: Pilot climb ladder 1.3.3: Greet and follow officer to bridge	Task 2.3: Maintain captain in loop 2.3.1: Include captain in communciation with port, tugboats and VTS. 2.3.2: Translation operational procedures to common language	Task 3.3: Talk with crew 3.3.1: Condition of vessel	Task 4.3: cognitive evaluation of economic impact on crew and captain decision making
	Task 2.4: General assessment 2.4.1: Pilot assesses vessel and crew 2.4.2: Pilot assessed by crew and captain	Task 3.4: Connect pilot laptop to pilot plug 3.4.1: Pilot's own laptop or tablet 3.4.2 Collect updated vessel data	
		Task 3.5: Adjust instruments and controls to pilot 3.5.1 Consult with third mate (or someone familiar with instrument and controls) 3.5.2: Adjust range and headinng of ECDIS	

5.0 Agree on route Goal: Mutual understanding and decision of best course of action	**6.0 Supervise navigation** Goal: Safe navigation to/from port	**7.0 Order and command tugboats** Goal: Efficient use of tugboats	**8.0 Berthing of vessel** Goal: Succefully berth and finalize operation
Task 5.1: Open ECDIS (or paper map) 5.1.1: Review plan with captain and crew 5.1.2: Decide route plan	Task 6.1: Closed-loop communication 6.1.1 With captain 6.1.2: With third mate 6.1.3: With helmsman 6.1.4: Other crew	Task 7.1: Evaluate and decide number of tugboats 7.1.1: Consider post and unsrance in case of emergency	Task 8.1: Pilot communicate with port coordinator 8.1.1: Receive port information 8.1.2: Receive meters to go forward 8.1.3: Receive meters to go astern
Task 5.2: Notify VTS about intended route 5.2.1: Receive confirmation that intended route is ok 5.2.2: Receive information about traffic in intended route	Task 6.2: Request to be challenged 6.2.1: Repeat pilot's commands 6.2.2: Cognitively understand that crew evaluate pilot exhaustion and competence	Task 7.2: Pilot-tugboat communication 7.2.1: Enable VHF or UHF communication with tugboats 7.2.2: Give information of where to attach 7.2.3: Give information regarding push and pull	Task 8.2: Give command to mooring crew 8.2.1: The type of mooring equipment 8.2.2: Side of mooring
Task 5.3: Discuss and plan berthing configuration 5.3.1: Mooring equipment 5.3.2: Line boat setup	Task 6.3. Ensure captain monitor operation	Task 7.3: Pilot coordinate tugboat and vessel 7.3.1: Set-up available means of communcation from brdige wing 7.3.2: Inform captain of available tugboats 7.3.3: Give third mate specs and parameter inputs of tugboats	Task 8.3: Coordinate line boats 8.3.1: Communicate with line boats 8.3.2: Lower berthing wire to line boat 8.3.3: Line boat transport wire to port
			Task 8.4: Finalize berthing 8.4.1: Vessel in position 8.4.2: Pilot exit vessel 8.4.3: Vessel all fast

Figure 2. Main tasks, tasks and subtasks in a pilotage operation

Tasks and functions are structured hierarchically following the steps of Annett et al. (1971) for conducting hierarchical task analysis. Baber and Stanton (1996) states that task analysis is a commonly used tool to structure tasks prior of subsequent investigative human factors analyses. The condensed results from the task analysis can be seen in Figure 2.

2.2.2 *Systematic Human Error Reduction and Prediction Approach (SHERPA)*

SHERPA concerns the identification of three common trends: (1) errors with a high probability of occurring, (2) errors which are deemed critical, i.e. substantial damage to vessel, personnel or yield environmental hazards, and (3) finding with a high frequency of the same error type, e.g. multiple errors are categorized as an action error (please see Table 1 for an overview of error categories). These are trends common in pilotage operations.

Critical consequences are defined binary (yes/no) in SHERPA. Error probabilities are defined in an ordinal manner in SHERPA; i.e. low probability is assigned errors which have never occurred, medium probability is assigned if it has occurred on previous occasions, and high probability are assigned if the error frequently occurs, and this data relies on historical trends and/or subject matter experts.

The information obtained using SHERPA can be used to understand which error types related to the various tasks in a pilotage operation and how to prevent or mitigate them.

Table 1. Error categories SHERPA

Error categories	Action errors Checking errors Retrieval errors Communication errors Selection errors

Furthermore, SHERPA may intrigue research with appealing hypotheses to investigate; that is, if you investigate relationships and frequencies of error types.

3 RESULTS AND ANALYSIS

The eight main tasks elaborated on above were investigated using SHERPA. Each main task was independently analyzed following an after followed an analysis of the overall error relationships and frequency distribution of errors

3.1 *Result hierarchical task analysis (HTA)*

The task analysis was structured hierarchically and in a timeline to give information about the complexity associated with pilotage operations. There was identified two non-sequential tasks (task 2 and 4) and 6 sequential tasks. The sequential tasks are generally (not strictly) conducted in the order presented above, whereas task 2 and 4 are continuously carried out across the other tasks as well. This is depicted in Figure 1 in the introductory section. However, the tasks are placed haphazardly in task 2 and 4 to show its significance to the overall process. As an example of deviation, it was noticed during the observation study that the pilot began weather assessment an hour before entering the vessel, to begin mentally planning and understanding the operation. The pilot was experienced and identified fog which must be accounted for while voyaging in confined waters. Frequency and distribution of tasks can be seen in Table 2 below, consistent with Figure 2 above.

Table 2. Frequency of main tasks, tasks and sub-tasks

Main tasks	8
Tasks	28
Sub-tasks	55

The task analysis did not go into more detail like motoric, mechanical and cognitive operations as it would not contribute further information to conduct SHERPA.

3.2 *Analysis of SHEPRA results*

The most frequent human error in pilotage operations are related to action omission (decision not to act), as revealed by SHERPA. The second most frequent type of errors are communication errors. Unfortunately, pilotage operations consist of much communication and are dependent on efficient and precise sharing of information to achieve a successful operation; additionally, this applies to formal as well as informal communication. Considering that the maritime industry employs crew from all over the world, cultural and language barriers put elevated strain on the communication aspect of the operation. This indicate a need to further investigate the relationship of communication and action omission.

Table 3 below shows an overview of error types, frequency of the respective SHERPA probabilities and tasks which were deemed critical. The table shows results for all 8 main tasks and in total for the overall operation. The table gives information about the most and second most frequent error type spread out on each main task respectively, with action error the most frequent overall and information error the second most frequent. The ordinal probability of errors is presented as well: Here we see that medium probability is most evident representing 27 of the 55 sub-tasks. The human error assessment reveal that there are 15 sub-tasks with a critical consequence of occurrence. There are two sub-tasks which are assessed to have high probability of occurrence and a potential for high consequence if the error is conducted: 2.1.2 and 3.2.1, please see Table 4 where these tasks are extracted from SHERPA.

Table 3. Most frequent error type, second most frequent error type, number of errors with low-, medium-, and high probability and number of errors with critical consequence distributed among eight main tasks discovered in HTA. P = Probability, C = Critical. Hyphen "/" indicates a tie.

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Total
1st most error type	Information/ Action	Action	Checking	None	Action	Information	Action	Action	Action
2nd most error type	Information/ Action	Information	Action	None	Retrieval	Action	Information	Retrieval/ Information	Information
Low P	1	0	3	0	0	0	7	6	20
Medium P	7	5	3	0	3	6	0	5	27
High P	0	4	2	0	1	0	0	0	8
No of Critical errors	2	3	2	0	2	6	2	0	15

Table 4. Tasks which are considered high probability of occurrence and potentially high consequence.

Sub-task	Error mode	Error description	Consequence	Recovery	P	C	Remedial strategy
2.1.2	I1: Information not communicated.	Uncertainty of who will have control of instruments and in various scenarios.	Evasive maneuvers omitted.	Clear statement of who will control which parts of the operation.	High	Yes	Ensure routines of clarifying control.
3.2.1	C1: Check omitted	Pilot not known to technical malfunctions.	Vessel not behaving accordingly, e.g. stern crash into port because lack of thruster.	Contact crew immediately regarding vessel technical status.	High	Yes	Pilot receive vessel technical condition prior to boarding vessel.

The extracted sub-tasks have error type regarding information and check omission. Sub-task 2.1.2 is to initiate talk regarding intent and expectations; most importantly, distribution of tasks among the pilot and crew, e.g. whom will maneuver the vessel while berthing. Sub-task 3.2.1 is a check of paramount importance that the pilot needs to do while installing him- or herself to the command bridge. With further interpretations of findings, it may be hypothesized that sub-task 2.1.2 and 3.2.1 are dependent or the same underlying mechanisms.

3.3 *Validity and reliability considerations*

Two independent researchers were introduced to sub-sections of the data to analyze findings, a common process to ensure reliability of qualitative analyses. Further subsequent validations were performed by two subject matter experts to ensure that the researchers have structured and analyzed the date consistency. The converged result among the researchers and subject matter experts was consistent.

The observation study of the real-life piloting operation functioned as part validation and part further data gathering, as consistent with the mentioned iterative nature of qualitative research. The results from

The observation study provided more evidence for reliable and valid findings from the human reliability analysis.

4 DISCUSSION

The findings in the current research shed light on human errors in pilotage operations that has potential to result in accidents (e.g. Godafoss, Federal Kivalina and Crete Cement accidents). Communication and action errors were found to be most prevalent in pilotage operations.

Detailed understanding of human error in pilotage operations are uncovered in the current research. This information is gathered using a qualitative approach which is a common way to deepen understanding of a topic in an exploratory manner, and to perhaps subsequently generate hypotheses that are of interest for the scientific community and/or industry to explore further. Several cognitive challenges that put load on the maritime operators were identified in the human reliability assessment conducted in this study. These cognitive challenges influence the overall mental capacity of the operators which affects the safety- and efficiency performance of the team. Action errors and information errors were found most prevalent in a pilotage operation. The frequency of errors was further analyzed to understand the underlying mechanics that impacts human reliability during pilotage operations.

4.1 *Potential underlying mechanics in pilotage operations*

There is a possible connection between omission errors and communication errors that emerges while studying the distribution and frequency of errors types. It is likely that this connection is the same as the underlying mechanics which impact the performance of 2.1.2 and 3.2.1.

This mechanic can be social climate. Social climate is commonly understood as antecedents of safety compliance (Neal et al. 2000): where safety compliance here is to check pilot cards (sub-task 2.1.2) and to perform intra-team communication (sub-task 3.2.1). Neal et al. (2000) found a factor loading between safety knowledge and safety compliance of .35 using structure equation modelling. Knowledge of safety behavior and safety compliance are tied. Figure 3 below shows connection between social climate, safety knowledge and safety compliance related to the most frequent errors revealed in the current study on pilotage operations. In this hypothesis, team communication skill is associated with a part of safety knowledge considering how communication training is focused on its safety and efficiency importance.

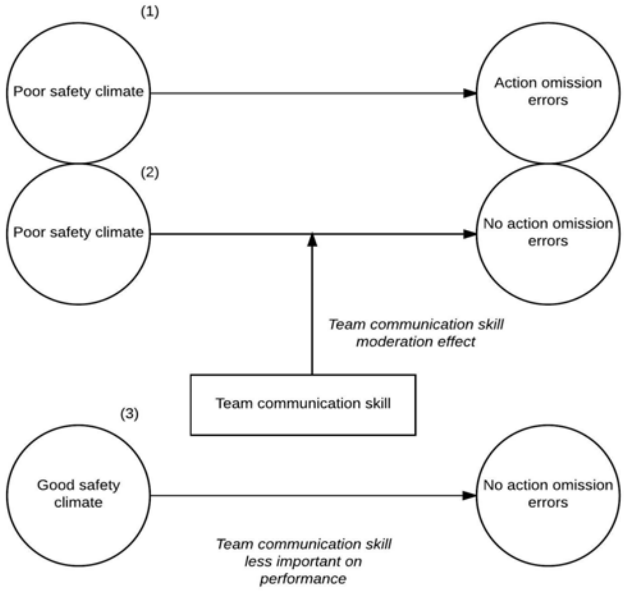


Figure 3. Effects between good and bad safety climate.

Effects (1) and (2) depict command bridges that have poor safety climate. The reason for poor climate can be manifold, for instance personality differences, pressure from ship-owners or lack of trust. Effect (2) includes that the pilot has relevant skill in team communication, an understanding of communication as a safety barrier acquired from training and experience, as well as how to carry out proper communication in stressful operations. In effect (3), the command bridge operates under a good safety climate. This render the skill on team communication (regarding safety knowledge) less important to ensure safe team performance: e.g. the team communicates intent and expectations and the pilot is incentivized (by the captain) to check pilot cards.

4.2 *Theoretical and practical implications*

Human errors will and are always conducted, it is not about making us robots but to pinpoint the errors that are most likely to occur Human error in pilotage operations are of concern because of the complexity that exists and the consequences that may occur following a human error. The prevalence and consequence of human error dictates a need to research and find measures to prevent them and mitigate the consequences if they do occur. and the reduce them.

The current findings are consistent with theoretical research on human errors. Communication and action errors are essential components to have safe and efficient working conditions for teams operating in complex sociotechnical systems such as pilotage operations. An underlying mechanism has been suggested that should be further investigated to understand how to improve communication and action execution.

Pilotage operations are expensive operations with an aim to ensure safe passage in constrained waters. The contribution of this research provide evidence that such operations are prone to communication and action omission errors. This should dictate a focus on these skills in training and selection of captains and pilots.

4.3 *Limitations*

The study has some limitations. In retrospect, there should be more standardization of the interviews. The open-ended interviews make room for flexible and pinpointed collection of data; however, in complex operations such as pilotage, the open-ended interviews tended to distort which parts of the operation received attention. At the same time, the relative high number of interviews justified this to ensure an overall understanding of pilotage. Another limitation is regarding SHERPA. The dynamic and complex nature of pilotage operations with several non-sequential tasks makes it a challenge to develop a consistent hierarchical task analysis (necessary input to SHERPA); insofar, this was combated with using a timeline representation of the tasks and by acknowledging non-sequential tasks to fit the most commonly used placement in the over operational procedure.

Reflexivity and subjectivity considerations are common limitations with qualitative studies. The analysts, interviewers and interviewees will systematically shed their attitudes, prior knowledge and experience on the findings and gathered data. Nonetheless, measures have been taken to reduce the issue of subjective influence on research, e.g. using other researchers when analyzing the data and the iterative nature of gathering data and interpreting data. To ensure that interviewees are not led in any directions, they were told that participation is voluntary and that the interview can be discontinued without any explanations. These measures are consistent and commonly mentioned to reduce subjective bias when performing qualitative analyses (Willig 2008).

5 CONCLUSION

Pilotage operations have potential of human errors where errors have high consequences. It is important to understand and identify tasks in such operations to effectively design layout and train operators according to the operational demands. This research revealed that pilotage operations are prone to errors which are dependent on the command bridge safety climate and suggests further experiments to quantify the causal relationships between action omission errors and safety climate.

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