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Texting while piloting:

A simulation study comparing verbal and written navigational instructions in shore-based deep sea pilotage

Diploma Thesis in the Master Mariner Programme

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Gothenburg, Sweden, 2013

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Abstract

Piloting has been used in seafaring throughout all times. The technological advances in recent years have led to much discussion of whether shore-based pilotage should be used, but not as much discussion about *how* such shore-based pilotage should be conducted. The purpose of this thesis is to investigate a specific part of the subject of shore-based pilotage; the difference between how piloting instructions transmitted using two different modes of communication, written and verbal, influence the behaviour of bridge officers when navigating, during shore-based deep sea pilotage.

In order to investigate this, an observational study was conducted in the Bridge Operations Simulator at Chalmers Campus Lindholmen's Simulation Centre. In the study, the participants navigated through a part of route-T through the Great Belt strait, while receiving navigational instructions over either VHF radio or a text based chat. After the simulation, a debriefing was conducted, in order to find out how the participants experienced the simulation, and to receive their comments regarding the use of the two modes of communication.

The study pointed to a number of tendencies, that combined led to the conclusion that the option of transmitting appropriate parts of the navigational instructions over a text based medium, when designing a system for shore-based deep sea pilotage, should not be overlooked.

Keywords: Shore-based pilotage, Land-based pilotage, Remote pilotage, Deep sea pilotage, Verbal communication, Written communication, MONALISA

Sammanfattning

Lotsning är någonting som har förekommit inom sjöfarten genom alla tider. De senaste årens tekniska landvinningar har gjort att det har börjat diskuteras mycket om huruvida landbaserad lotsning skall användas, men inte fullt lika mycket om *hur* den landbaserade lotsningen i så fall skall utföras. Detta examensarbete syftar till att utreda en specifik del av ämnet landbaserad lotsning; skillnaden mellan hur navigationsinstruktioner överförda via två olika kommunikationssätt, skrift respektive tal, påverkar beteendet hos bryggbefäl under deras navigation vid landbaserad långlotsning.

För att undersöka detta genomfördes en observationsstudie i bryggsimulatorn vid Chalmers Campus Lindholmens simulatorcentrum. I studien fick försöksdeltagarna navigera genom en del av rutt T genom Stora Bält, samtidigt som de erhöll navigationsinstruktioner via antingen VHF-radio eller en textbaserad meddelandefunktion. Efter simuleringen genomfördes en debriefing för att få reda på hur försöksdeltagarna upplevde simulationen, samt för att få deras kommentarer angående användandet av de två kommunikationssätten.

Studien påvisade en rad tendenser som sammanvägda ledde till slutsatsen att man inte bör förbise möjligheten att överföra lämpliga delar av navigationsinstruktionerna över ett textbaserat medium när man utvecklar ett system för landbaserad långlotsning.

Nyckelord: Landbaserad lotsning, Fjärrlotsning, Långlotsning, Verbal kommunikation, Skriftlig kommunikation, MONALISA

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Definitions

AIS	Automatic Identification System, a tracking system that can identify and locate nearby ships as well as provide additional ship specific information.
Closed loop	A communication technique where the receiver of a message repeats the message back to the sender, and the sender confirms that the message was correctly repeated. This technique, common in verbal maritime communication, is used in order to avoid errors in the transfer of the message.
Deep sea pilotage	Pilotage in open water such as the Baltic or the waters between Sweden and Denmark. In contrast to harbour pilotage or pilotage in river mouths.
ECDIS	Electronic Chart Display and Information System, computerised navigational charts showing route plan and own ship position. It also shows the position of other nearby ships equipped with AIS.
GPS	Global Positioning System, a satellite based system that enables a ship to automatically determine its position with the use of signals from a constellation of navigational satellites.
IMO	The International Maritime Organization, a United Nations organ concerned with the safety and security of the maritime industry as well as preventing marine pollution.
NASA	The National Aeronautics and Space Administration, the United States agency responsible for their civilian space program as well as aeronautical research.
NAVTEX	Navigational telex, an automated service for delivery of navigational and meteorological warnings, as well as marine safety information.
OOW certificate	Certificate of competence for an officer in charge of navigational watch, any certificate in accordance with STCW Regulation II/3 or higher, allowing the holder to be in charge of a navigational watch on their own. For example the Swedish *Fartygsbefäl klass V*.

Pilot	A person with expert knowledge of a specific area, who boards the ship and becomes a part of the bridge team in order to guide the ship safely through its route.
Shore-based pilotage	Pilotage of a vessel by a licensed pilot that is not present aboard the vessel but located ashore.
SMCP	Standard Marine Communication Phrases, a set of phrases used in marine communication, developed by the IMO.
STCW	The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, an IMO convention setting qualification standards for the competency of seagoing personnel.
TSS	Traffic Separation Scheme, a traffic management system in a specific area, put in place by the IMO, in order to separate the traffic in different lanes where the traffic flows in the same general direction.
VHF	Very High Frequency, the frequency band used for marine radio communication.
VTS	Vessel Traffic Service, a marine traffic monitoring system established by harbour or port authorities to keep track of vessel movements and to increase the navigational safety in a limited geographical area.

1 Introduction

1.1 Background

Ever since ships began sailing on the seas, there has been a need for them being guided by pilots. Normally this is achieved by the pilot boarding the vessel and using his or her expert knowledge of the area to instruct the ship's crew in the safest way through the intended route. However, some European ports have, in some special cases, begun using a rudimentary form of shore-based piloting instead. This practice is only used when severe weather conditions prevent a pilot from boarding the ship at the regular boarding point. The ship is then guided using VHF radio communication to a different location where the sea state is calmer, and a pilot can board in order to continue guiding the ship (Hadley, 1999). It has been noted that if this method of shore-based piloting works in bad weather conditions, there is no reason to why it should not work in calmer weather, at least in low intensity piloting situations (Lützhöft & Bruno 2009). Such situations could be deep sea piloting in areas where piloting normally is not mandatory for the vessel in question.

The idea of shore-based pilotage has thus come into focus and there are now research projects studying the area, one example being the MONALISA 2.0 project at the Lighthouse Maritime Competence Centre at Chalmers University of Technology in Gothenburg. During shore-based pilotage, the pilot is located in a control centre ashore where he or she can follow the ship's movements using AIS, radar or other means of positioning and gives navigational instructions to the ship's crew. One means of transferring the information from the pilot to the ship is via VHF radio communication and this is the method used today (Bruno & Lützhöft, 2009). Another method that could be made possible, due to technological advances such as ECDIS and AIS, is sending the navigational instructions as text messages to the ship. Even though it currently is possible to send simple text messages via the ship's AIS, this function is not very user-friendly and is not intended to be used as a live two-way chat. A better way of sending these messages would be to present them in some form of chat window in the display of the ship's ECDIS. Although such a means of sending text messages to the ship's ECDIS is not currently available in the products on the market now, part of the MONALISA 2.0 project is researching how such a system should be designed and what features it should have.

This thesis will explore the difference, if any, between VHF radio communication and text based real-time communication. There has been very little research in this particular area and the conclusions of this study will hopefully be of value to the MONALISA 2.0 project, as well as other research projects.

1.2 Purpose

The purpose of this thesis is to investigate the difference in how information delivered through two modes of communication, written and verbal, will influence the behaviour of bridge officers when navigating. The information communicated will be navigational information and instructions of the type that might be transmitted by a shore-based pilot, during deep sea pilotage, to aid in the navigation of a vessel.

1.3 Research questions

- In what way does the communication of instructions through text rather than voice during shore-based deep sea piloting affect the receiver's comprehension of the instructions?
- In what way does the communication of instructions through text rather than voice during shore-based deep sea piloting affect the receiver's response behaviour?

1.4 Delimitations

This thesis is limited to shore-based deep sea pilotage in low risk situations where pilotage is not mandatory but voluntarily requested by the vessels or recommended by authorities. This thesis will not treat shore-based pilotage in harbours, river mouths or other such areas where pilotage is normally mandatory for average sized merchant vessels not carrying dangerous goods. This thesis will also not treat the advantages and disadvantages of shore-based pilotage.

2 Theory

2.1 Earlier research on shore-based pilotage

Bruno & Lützhöft (2009) point out that the act of piloting can be seen as a control problem. When the pilot is moved from aboard the ship being piloted to a location ashore, the level of control decreases. However, they also draw the conclusion that, since a rudimentary form of shore-based pilotage is already used in some ports during hard weather conditions, it is reasonable to assume that it also should be possible to successfully perform shore-based pilotage when the weather situation is calmer, at least for some ships and in some situations.

Earlier studies have concluded that shore-based pilotage will not be a viable option for all vessels or in all situations. There is a consensus among researchers that the ships that could be suitable for shore-based pilotage are those with good manoeuvrability, and with a competent crew (Hadley & Pourzanjani, 2003; Grundevik & Wilske, 2007; Bruno & Lützhöft, 2009). An additional criterion, given by Lützhöft & Bruno (2009), is that shore-based pilotage should only come in question for low intensity piloting situations.

In earlier research it is also stressed that, during shore-based pilotage, it is necessary for all parties involved in the communication to use a standardised, common language and phrases, like those defined in IMO's SMCP (Hadley & Pourzanjani, 2003; Lützhöft & Bruno, 2009).

2.2 Earlier research on verbal and written instructions

There has been earlier research comparing the auditory and visual modality of message presentation. In one such study made on behalf of NASA they found little overall difference between the two modalities, however with a slight advantage to the auditory modality (Schneider & Healy, 2000). One reason for this disadvantage to the visual modality could be that they only let the test subjects see the visual presentation of the message the same amount of time as the duration of the auditory message. This led to the necessity of reading fast enough to be able to see the whole message as well as remembering the message after the text had disappeared.

One conclusion that could be drawn from the study was that there is a correlation between the length of the message and how well it was received. As the length of the message was increased, the greater was the decline in performance (Schneider & Healy, 2000).

3 Method

3.1 Choice of method

In order to answer this thesis' research questions it was decided that a semi-structured qualitative observation study should be conducted in the Bridge Operations Simulator at Chalmers Campus Lindholmen's Simulation Centre. During the simulation the participants received a number of navigational instructions in either verbal or written form. The behaviour of the participants was observed, and after the simulation a debriefing was held, in order to also get an insight into their first-hand experience, as well as receiving their comments.

3.2 Selection of participants

Ideally the participants acting as bridge officers, conducting the navigation and receiving the navigational aid, would all be seafarers holding OOW certificates. Due to limitations in time and resources this was difficult to achieve, therefore about half of the participants were students from the Master Mariner programme at Chalmers.

The last year students have completed most of the relevant courses in seamanship, navigation and ship manoeuvring as well as a majority of their seagoing cadet time. Navigation wise, their performance should not be too far from that of a recently graduated officer of the watch.

3.3 Construction of the simulation scenario

3.3.1 Choice of area

For the simulation, a part of route-T was chosen; the passage through the Great Belt strait. This area was chosen as it is an area available in the simulator where it is highly recommended, but not mandatory, for all ships with a draught of 11 meters or more to take a pilot (The Danish Maritime Authority, 2013).

In this area, the north bound traffic lane was chosen over the south bound traffic lane as it offered more options in creating realistic and relevant instructions.

3.3.2 Choice of vessel

The vessel navigated by the participants was chosen to be large enough to be recommended to take a pilot, but not of the type for which pilotage is mandatory. A ship model named CNTNR20X in the simulator was chosen. It is a container ship with a length over all of 294 meters, a breadth of 32 meters and a draught of 11 meters. The vessel has a displacement of 63 463 cubic meters, an engine output of 48 640 kW, a single fixed-pitch propeller and a single rudder.

3.3.3 Choice of traffic intensity, weather and environmental factors

The traffic intensity in the simulation was chosen to be moderate, with a few ships following the same traffic lane, going north, and a few ships in the south going traffic lane. One ferry was crossing the traffic lane from the east, ahead of the participants' vessel, and one ferry later crossed the traffic lane from the west, passing aft of the participants' vessel. One ship also joined the traffic lane from the east. None of the vessels would interfere with the navigation of the participants' vessel as long as the participants followed the intended route and did not alter the speed of the vessel.

The time of day in the simulation was chosen to be in the morning at 8 am, after sunrise. The weather situation in the simulation was chosen to be clear skies, and moderate wind and current.

The reasons for these choices in traffic intensity, time of day and weather were to make the situation feel realistic but without taking focus from the navigation or the communication with the shore-based pilot.

3.4 Preparation of the navigational aid

3.4.1 Choice in the number of instructions

The limiting factor in the practical number of navigational instructions given during the simulation was the duration of the simulation. During a trial run in the simulator it was determined that one instruction every ten minutes probably would be ideal in this case. If the instructions were spaced more tightly the next instruction would arrive before the first one was fully executed. With about half an hour of simulator time per run this yielded three instructions per simulation.

3.4.2 Instruction 1

"An uncharted obstruction has been reported in position 55° 17,5' N 011° 04,0' E. All ships are advised to keep a distance of at least 2 cables from this position."

This instruction was designed to be a clear and concise instruction of the type usually transmitted as navigational warnings through NAVTEX or other similar communication channels, and containing a position spelled out in the form of latitude and longitude.

3.4.3 Instruction 2

"Due to migrating sandbanks the charted depth in the eastern lane of the TSS may be incorrect. To avoid unexpected squat or banking effects it is recommended that you keep in the westernmost half of your traffic lane during the transit through the TSS under the Great Belt Bridge."

This instruction was designed to be less strict and concise and instead more "chatty," with superfluous information about the background and the consequences in a manner more akin to how a navigational instruction might sound if given by a pilot located aboard the vessel.

3.4.4 Instruction 3

"Due to a strong anomalous easterly current in the area north of the Great Belt Bridge it is recommended that you keep tight on the fairway buoy no 26 as you turn around it to course 327°, but do not cross over into the oncoming lane."

This instruction was intentionally malformed. As can be seen from figure 1, the fairway buoy no 26 is the second to last fairway buoy and as such it is impossible to turn around it to course 327° without crossing over into the oncoming lane, the instruction as such is logically inconsistent. This instruction was designed to determine whether the participants would ask for clarification, or just go ahead with their assumption of what was intended.

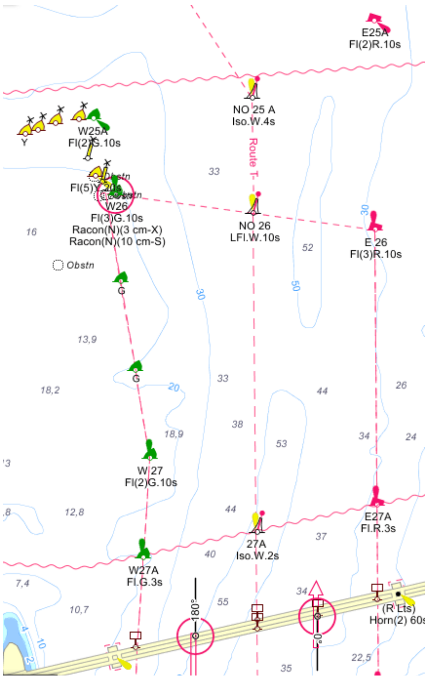

Figure 1
Extract from a nautical chart showing the buoys in the northern half of the TSS under the Great Belt Bridge. The buoy referred to in instruction 3 is the second buoy from the top in the middle column (Krak, 2013).

3.5 Design of the communication software

The verbal communication took place over the simulator's VHF radio, but the simulator lacked a communication channel for written communication. A very simple chat program was programmed in Java, based on a conceptual sketch of the MONALISA chat window, provided by Dr Thomas Porathe.

The program is very simple, and once up and running presents the user with two text areas and a transmit button. Outgoing text messages are entered in the lower text area and transmitted either by clicking the transmit button or by pushing the enter key on the keyboard. After being transmitted, it remains visible in the upper text area together with the incoming text messages. Each separate text message in the upper area is time stamped, marked with the senders name and appears on a new line, chronologically arranged with the newest message at the bottom. Once the entire text area is filled with text, it becomes scrollable.

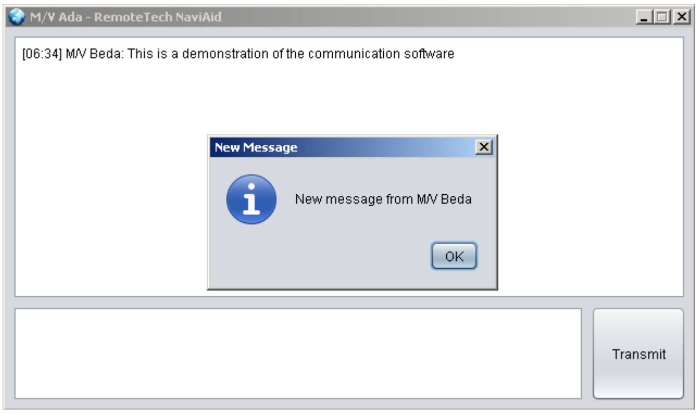

Figure 2

The communication software running in a Windows environment, showing the pop up window notifying the user of a new text message from the vessel M/V Beda.

Each time a new text message is received, a pop up window informing the user of the new text message will appear, as shown in figure 2, and an alarm will sound until the text message is acknowledged either by clicking the OK button or by pushing the enter key on the keyboard.

3.6 Execution of the simulation

3.6.1 Briefing

Upon arrival the two participants were greeted jointly and presented with a letter of consent. They were then briefed with the scenario; they were serving as a junior officer aboard a container ship in transit through the Great Belt area. The vessel was not going to take a pilot during the transit, but the vessel had signed up for a service where they would receive navigational aid from a shore-based company that was aggregating navigational information from around the world, and presenting it to the subscribing vessels at an appropriate time.

Furthermore, they were informed that one of them would be receiving the navigational aid over VHF radio and that one of them would be receiving the navigational aid in written form on a computer screen. In both cases the communication would be two-way, and if they felt that it was necessary they could ask follow up questions. When the scenario was established they were randomly assigned to either bridge by the flip of a coin.

Once on the bridge, the individual participant was given a briefing about the pre-planned route and the traffic situation, and in the case of the participant who would receive written instructions, a brief run-through of the functionality of the text based chat software.

3.6.2 Simulation

In order to deal with the limited time in the simulator, both simulations were run at the same time. The two simulations took place in identical but separate worlds, so that the actions of one participant would not affect the other. In order to avoid having to communicate with both bridges at the same time, the second simulation was started five minutes after the first simulation was started. The two bridges were separated from each other, but in order to make absolutely sure that the second participant would not overhear the navigational instructions given to the first participant and become influenced, the simulation using written communication was always started ahead of the simulation using verbal communication.

The two bridges were equipped with identical equipment, with the only difference being an additional computer, running the text based communication software, located on the starboard side of the bridge between the radar and the chart table, on the bridge that would receive written instructions, as can be seen in figure 3.

Figure 3

A photo showing one of the simulator bridges used in the study. The VHF radio handset can be seen in the forward right part of the centre console, in front of the conning display, and the MacBook Air running the text based communication software can be seen on the table to the right of the starboard console.

3.6.3 Observation and interaction

Once the simulation was up and running, the participants were mainly observed through the use of the simulator's observation system. This system consisted of a live video feed of the participants' bridges and a live feed showing duplicate presentations of the radar screens, conning display and visual view, identical to how they were presented to the participants. This allowed the observation of the participants' behaviour on the bridges, as well as the way in which they used the navigational equipment. The observations of the behaviour were documented by note-taking and the simulation was recorded and saved for later analysis.

During the simulation, the participants were interacted with in two ways; communication over VHF radio or the text based chat with one of the authors, posing as a shore-based deep sea pilot, and face to face communication with the other author, posing as the master of the vessel. The interaction of the shore-based deep sea pilot can further be divided in to two categories; issuing the instructions, and responding to the participants' questions.

The instructions were issued to the participants at the following times in the simulation:

- The first instruction was issued fifteen seconds after the simulation was started, approximately when the vessel crossed the latitude parallel of 55° 12,7' N.
- The second instruction was issued when the individual participant's vessel crossed the latitude parallel of 55° 16,9' N.
- The third instruction was issued when the individual participant's vessel passed the lighthouse Oesterrenden S E 28, approximately when the vessel crossed the latitude parallel of 55° 19,5' N.

When the position, in the form of latitude and longitude, in instruction 1 was issued over VHF radio, the position was read out twice in accordance with standard radio communication practice.

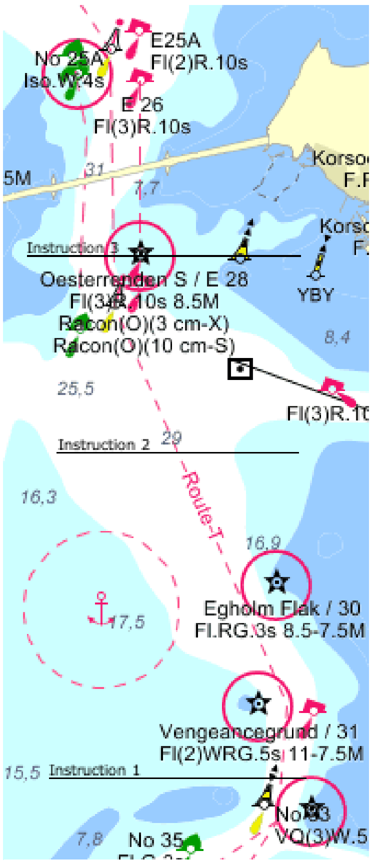

Figure 4

Extract from a nautical chart showing the latitude parallels at which the instructions were issued (Krak, 2013).

The questions answered by the pilot were of two types; requests of repetition of instructions or parts thereof, and requests for further information or clarifications.

The face to face interaction between the individual participant and the master of the vessel took place when the ship passed between the buoys 27A and E27A, approximately when the vessel crossed the latitude parallel of 55° 20,8' N. The author posing as the master entered the bridge, presented himself as the master of the vessel, and asked a general question on how everything was going and if there were any uncertainties regarding the navigation, without specifically mentioning the third instruction. This was done in order to determine whether the participants had registered the fact that the third instruction was inconsistent.

3.6.4 Debriefing

When the simulation was finished, the participants were invited to a joint debriefing. The debriefing was conducted in a semi-structured fashion with open ended questions encouraging the participants to reflect upon their performance during the simulation, and their view of how well the two different modes of communication worked in this situation.

The debriefing began with a general question regarding how the participants experienced the simulation in general, in order to get the participants talking. The debriefing proceeded with general questions regarding the instructions, discussing one instruction at a time. This was followed by specific questions on how the participants had interpreted the meaning of the second and third instructions, and why they had interpreted them in the way that they did. Finally, the participants were invited to reflect freely on the simulation, the different modes of communication, and to generally discuss communication in shore-based deep sea pilotage. The debriefing was documented by note-taking.

3.7 Methodological critique

Methodological critique will be presented in the discussion section of this thesis.

4 Results

4.1 Instruction 1

“An uncharted obstruction has been reported in position 55° 17,5’ N 011° 04,0’ E. All ships are advised to keep a distance of at least 2 cables from this position.”

4.1.1 Observations

Out of the four participants who were communicating over VHF radio, all four responded in some way to the given instruction. Two participants responded with proper closed loop communication. One of the participants misunderstood the given position, but this was discovered and corrected in time due to the use of closed loop communication. None of the participants who were communicating over VHF radio asked any additional questions.

Out of the five participants who were communicating over the text based chat, two responded in some way to the given instruction. None of the participants responded with closed loop communication. None of the participants misunderstood the position. One of the participants who were communicating over the text based chat asked follow up questions pertaining to the safe speed at passing the obstruction as well as directions to whether going east or west of the obstruction was recommended.

The movement patterns on the bridges of the four participants who were communicating over VHF radio were similar. All of the participants stood by the VHF radio located at the centre console as they received the instruction and wrote it down on a piece of paper. They then walked over to the chart table with their note and plotted the position before continuing with the navigation.

The movement patterns on the bridges of the five participants who were communicating over the text based chat were more diverse. Four of the five participants kept the position in their head as they transferred it from the computer, located at the starboard console, to the chart table. One participant wrote down the position on a piece of paper. Once the position was plotted in the chart, three of the five participants then went back to the computer and reread the instruction before continuing with the navigation. One of those three participants wrote back and asked the above stated follow up questions.

	Students	Officers	Both
Voice	9 m 0 s (1)	12 m 0 s (3)	11 m 15 s (4)
Text	10 m 20 s (3)	7 m 0 s (2)	9 m 0 s (5)
Both	10 m 0 s (4)	10 m 0 s (5)	10 m 0 s (9)

Figure 5

A table of the average times between the start of the transmission of the instruction and the completion of the corresponding evasive action for the various groups, as well as the number of test subjects in each group.

The time it took from the point at which the transmission of the instruction begun until the point at which the turn brought into action as a result of the instruction was completed and the ship's heading line was pointing outside of the area that was to be avoided, was on average the same for the participants from the group consisting of last year students and the participants from the group consisting of nautical officers.

The participants who were communicating over the text based chat took, on an average, two minutes and fifteen seconds less than the participants who were communicating over VHF radio to complete the same turn, as can be seen in figure 5.

4.1.2 Participants' reflections

One of the participants who had been communicating over the text based chat said during the debriefing that he at first, unconsciously, did not read the whole instruction. He stated that he only read up to the point of the position and then went to the chart table to plot that position. It was not until he had plotted the position and went back to the computer that he read the rest of the instruction, including the distance to be kept to the obstruction.

After hearing the first participant's statement, as seen above, the other participant, who had been communicating over VHF radio, said that he did something similar: he claimed that he wrote down the position and the distance to be kept to it, but then forgot about the distance during the chart work, and was not aware of it again until he reread his own note.

4.2 Instruction 2

“Due to migrating sandbanks the charted depth in the eastern lane of the TSS may be incorrect. To avoid unexpected squat or banking effects it is recommended that you keep in the westernmost half of your traffic lane during the transit through the TSS under the Great Belt Bridge.”

4.2.1 Observations

Out of the four participants who were communicating over VHF radio, all four responded in some way to the given instruction. One participant responded with proper closed loop communication. Two of the participants responded with a rudimentary type of closed loop communication, but left out the repetition of some of the vital parts of the instruction. One of the participants did not use closed loop communication at all when responding to the instruction. One of the participants asked for the question to be repeated and then asked if it was correct that they were to travel in the western – that is the south going – traffic lane. After receiving the reiteration that they were to go in the “westernmost half of the eastern lane,” the participant in question then responded with “OK.”

Out of the five participants who were communicating over the text based chat, two responded in some way to the given instruction. None of the participants responded with closed loop communication. None of the participants who were communicating over the text based chat asked any additional questions.

4.2.2 Participants’ reflections

Out of the four participants who had been communicating over VHF radio, two of the participants stated that they interpreted the instruction only to concern the area south of the Great Belt Bridge. The other two participants stated that they interpreted the instruction to concern the entire length of the TSS, both north and south of the bridge.

All of the five participants who had been communicating over the text based chat stated that they interpreted the instruction to concern the entire length of the TSS, both north and south of the bridge.

4.3 Instruction 3

"Due to a strong anomalous easterly current in the area north of the Great Belt Bridge it is recommended that you keep tight on the fairway buoy no 26 as you turn around it to course 327º, but do not cross over into the oncoming lane."

4.3.1 Observations

Out of the four participants who were communicating over VHF radio, all four responded in some way to the given instruction. One participant responded with proper closed loop communication. Three of the participants did not use closed loop communication. Two of the participants asked for the instruction to be repeated. One of the two participants who asked for the instruction to be repeated then immediately moved over to the chart table and studied the nautical chart while the message was repeated.

Out of the five participants who were communicating over the text based chat, two responded in some way to the given instruction. One responded right away after reading the message with the message "well received," and the other one responded with the message "OK" approximately four minutes after reading the message. None of the participants responded with closed loop communication.

None of the participants who were communicating over VHF radio asked for a clarification of the malformed message. When probed by the master of the vessel, all four participants stated that there were no uncertainties about the upcoming situation. Two of the participants mentioned that the pilot had given a somewhat confusing instruction, but that they assumed that it obviously was the fairway buoy no 25A that they were supposed to turn around. One of the participants, however, explained that the pilot had instructed him to keep tight on the lateral buoy no 26E as he turned to course 327°, which the participant in question also later did.

Three of the five participants who were communicating over the text based chat wrote back to the pilot, asking if he perhaps was referring to the fairway buoy no 25A. Two of the participants did not ask any such questions. When probed by the master of the vessel, all five participants stated that there were no uncertainties about the upcoming situation. Two of the three participants who had asked about which buoy to turn around mentioned that the pilot initially had sent an incorrect instruction but that it later, upon questioning, had been corrected.

4.3.2 Participants' reflections

Out of the six participants who did not ask for clarification about which buoy to turn around, five participants explicitly stated during the debriefing that they interpreted that the instruction was indeed to keep tight on fairway buoy no 26, but to turn around fairway buoy no 25A.

One of the participants who did not ask for clarification, stated during the debriefing that he interpreted that the instruction was to keep tight on the lateral buoy no 26E. This participant, who was one of the active navigational officers, further stated that this assumption was based on him mistakenly believing that the easterly current would cause the ship to drift towards the west, in which case it would have been logical to assume that he should position his vessel in the easternmost part of the traffic lane to compensate for the current. He also stated that he, upon re-examining his own note, was a bit unsure about whether the pilot had actually said something about the course 327°, spelled out "three-two-seven," or something about the lateral buoy E27, spelled out "E-two-seven."

4.4 General reflections from the participants

4.4.1 Reflections regarding misunderstandings

One of the participants, who had been communicating over VHF radio, stated that he felt it was easy to miss vital parts of the message, for example to only hear the word "buoy" when the message was referring to a "fairway buoy."

Another participant, who had been communicating over the text based chat, mentioned that, due to the fact that the text messages would remain in the message log, the next officer taking over the watch would not have to rely on second hand information from the previous officer but could instead read the original messages himself.

Three of the participants expressed the feeling of comfort in being able to go back and read the instructions several times to make sure no part of the message was overlooked or misinterpreted.

4.4.2 Reflections regarding memorisation

Three of the participants reflected on the necessity of writing down the message when receiving it over VHF radio in order to remember it. One of the participants commented that even though the participants in the simulation had pen and paper readily available, this is not always the case in real life situations, and that writing down the message is not necessary when using the text based chat.

4.4.3 Reflections regarding the time aspect

Out of all nine participants, six participants stated that they felt there was a reasonable amount of time between the instructions and the points at which action needed to be made. One participant, who had been communicating over the text based chat, expressed the feeling that the second instruction could have come a bit earlier. The remaining two participants, who had communicated over VHF radio, expressed the feeling that all of the instructions came too late.

One of the participants, who had been communicating over VHF radio, reflected on the perceived expectation of the receiver to drop the task at hand and immediately respond to radio communication. Another participant, who had been communicating over the text based chat, expressed the feeling that it was easier to choose when to read the message and for instance finish the task at hand before tending to the communication.

5 Discussion

5.1 Discussion of method

Initially the plan was to conduct a quantitative study, quantifying and measuring the deviation from the well-defined navigational behaviour intended to be induced with the communication. Due to limitations in time and resources it was soon made obvious that the experimental sample would have been far too small to ensure statistical validity using a quantitative method. Instead it was decided that a qualitative study should be conducted, more closely observing the participants' behaviour on the bridge, and then performing a debriefing after the simulation, where the participants would be able to share their reflections and thoughts about their behaviour and the communication.

Faced with the low number of available participants, it was tempting to let each participant run the simulation twice, once for each mode of communication. Should this have been done, it would have generated a larger set of data. In addition, the participants would also have been able to reflect on their experience of the differences between the two modes of communication. However, this would also have led to a bias in the result due to the fact that the participants would already have known the upcoming instructions ahead of time during the second run. It would have been possible to partially counteract this bias by constructing two different scenarios, but due to limitations in time and resources this was not a viable option.

In this study, the distribution of participants between the two modes of communication was entirely random. When reviewing the results, it was discovered that this led to a somewhat skewed distribution, since only one out of the four students received the instructions verbally and three of the students received the instructions in text. The corresponding distribution in the group of officers was that three out of the five officers received the instructions verbally and two of the officers received the instruction in text. Considering the way that the experiment was set up, it was not possible to run two simulations using the same mode of communication simultaneously in order to alleviate this problem. In retrospect, however, it would have been possible to schedule the participants in such a way that the distribution would have been more even.

Initially, when planning the study, it was discussed whether a questionnaire should be filled out by the participants after the simulation. Such a questionnaire could have been constructed with open-ended questions in order to yield qualitative data. However, it was decided that instead having a verbal debriefing after the simulation would lead to the participants giving longer and more elaborate answers to the questions, leading to a higher quality of the data.

As Golafshani (2003) points out, judging reliability and validity in qualitative research, as opposed to quantitative research, is not a trivial task. The reliability of this study can, and perhaps should, be questioned. There are many ways to interpret and explain the behaviours observed, and it is hard, if not impossible, to deduce facts from the results. With this in consideration, it was decided that the analysis of the results should be focused on identifying tendencies in the behaviour, rather than on acquiring factual statements on specific behaviour. While the reliability of this study could be questioned, the replicability of the observational study should be fairly high.

Regarding validity, it must also be noted that all of the participants were Swedish, and relatively young. Their ages spanned from early-twenties to mid-forties, with the average age being 26 years old. As such, the sample is not representative of the general population of navigational officers, and the results have a fairly low validity if generalised to the entire population. However, if generalised to the subpopulation consisting of Scandinavian and Western European navigational officers in their twenties or thirties, the results should have a fairly high validity.

5.2 Discussion of results

5.2.1 Tendencies in response behaviour

One of the most striking differences between the two modes of communication was the difference in tendency for the receiver to respond to the messages. All the participants who had been communicating over VHF radio responded in *some* way, be it only a short “OK” or by using proper closed loop communication. The participants who had been communicating over text based chat did not always respond. Some participants chose to respond to every text message with a short acknowledgement, whereas others only responded when they needed a clarification of the message. This might be due to the fact that there at the present time is no formal education in the use of real time text communication during the training to become nautical officers, as there is for radio communication (International Maritime Organization, 2011).

None of the participants who had been communicating over the text based chat used closed loop communication. One factor leading to the lack of closed loop communication by the participants using the text based chat might be the fact that all sent and received messages are readily available in the message log to both parties of the communication. As Grech et al. (2008) states, one of the primary reasons for using closed loop communication is reducing the risk of the message received not being identical to the message sent. When both parties in the communication have all the sent and received messages readily available and they have no apparent reason to mistrust the system’s technical integrity, the perceived need to use closed loop communication seems to be reduced. However, another point raised by Grech et al. (2008) is that it is easier to recognise that a mistake has been made if the message is spoken out loud. This positive aspect of closed loop communication is lost when using text based communication in the way it was used in the simulation study of this thesis.

There was also a difference in the type of questions asked by the participants using the two different modes of communication. The participants who had been communicating over VHF radio had a strong tendency to only ask for general repetition of information already given, whereas the participants who had been communicating over the text based chat tended to ask for additional information or for specific clarification of already given information.

5.2.2 Tendencies in assumption behaviour

Another difference between the two modes of communication was the difference in tendency to make assumptions. The participants who were communicating over the text based chat were less prone to make unfounded assumptions regarding the instructions, and were more prone to ask follow up questions when needed because of contradictions in the instructions.

When interpreting the second instruction, some of the participants who were communicating over VHF radio assumed that the instruction only concerned the southernmost half of the TSS although the wording of the instruction warranted no such assumption. This might be an effect of the combination of the participants communicating over VHF radio not being able to recall the literal wording of the instruction, and the fact that the shallowest depths in the TSS are found in the southernmost part of the north going traffic lane, as can be seen in figure 6. This could make it inviting to assume that the instruction was referring to a certain part of the TSS when in fact it was referring to the entire length of the TSS.

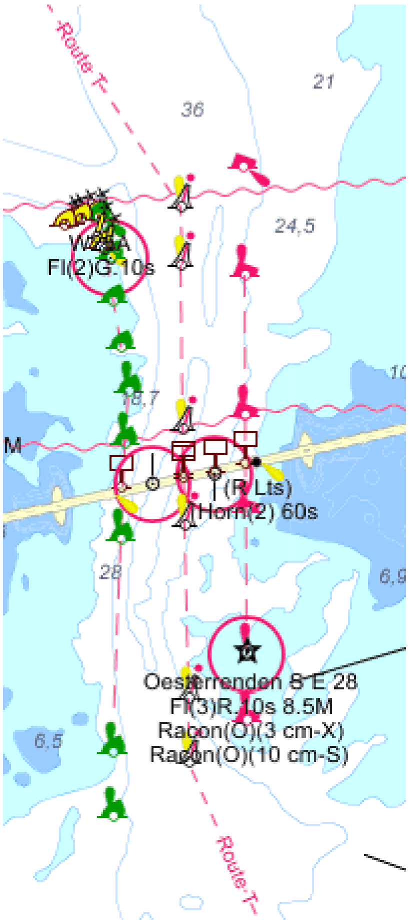

Figure 6

Extract from a nautical chart showing the TSS under the Great Belt Bridge with the areas shallower than 20 meters coloured in light blue and the areas shallower than 10 meters coloured in dark blue (Krak, 2013).

When interpreting the third instruction, the participants who were communicating over VHF radio seemed to base their assumptions on fragments of information and certain keywords in the instruction. It seemed as though they tended to mentally reconstruct the message into a shorter form based on perceived keywords, such as "current – easterly – keep tight – buoy – turn" for instruction 3. This could be observed in the wording of the responses from the participants using closed loop communication. It is not unreasonable to speculate that the other participants who were communicating over VHF radio, but did not use closed loop communication, mentally reconstructed the message in a similar way.

There were, however, very few assumptions made regarding the first instruction by the participants communicating over VHF radio. One reason for this could be that the length of instruction 1 was considerably shorter than the length of instructions 2 and 3. This would be in accordance with the findings of Schneider & Healy (2000), where performance declined with increased message length. In contrast to Schneider & Healy (2009) however, this correlation between message length and decline in performance was not as apparent in the case of the participants using the text based chat. The reason for this is most likely due to the fact that the text messages in the Schneider & Healy study were only shown for a brief period of time, whereas the text messages in this study remained visible for the participants indefinitely.

5.2.3 Discussion of the time aspect

The average time from the beginning of the transmission of the instruction, to the point at which the corresponding action had been completed, was shorter for the participants who had been communicating over the text based chat. This can be attributed to the time it took to transmit, and in some cases repeat, the instructions. When the instruction is sent as a text message, the recipient can read it at normal reading speed, whereas if the instruction is sent over VHF radio, it has to be read out aloud at a speed slow enough for the recipient to correctly receive it, and also be able to write it down. It might also be necessary to repeat important parts of the instruction, or in some cases the entire instruction. This naturally leads to a longer period of time before action in accordance with the instruction can be taken.

Some of the participants reflected on the perceived expectation to immediately tend to VHF radio communication, whereas some of the participants who had been communicating over the text based chat stated that they felt that they could choose, to a larger extent, when to tend to the communication. While the increase in freedom of choice of when to tend to the communication can lead to a decrease in the level of stress perceived by the navigational officers, this can lead to an increased risk of not tending to time-critical communication in time. However, this increased risk can be mitigated by dividing information into two different categories; information that is time-critical and information that is not time-critical. The information that is time-critical is probably best sent over VHF radio, whereas the information that is not time-critical can be sent over the text based chat. In fact, by transmitting all information that is not time-critical over a text based medium, instead of over VHF radio, the risk of non-time-critical communication tying up the VHF channel when time-critical information needs to be transmitted is reduced.

6 Conclusions

6.1 Conclusions

A number of conclusions can be drawn from this study:

- When using a text based mode of communication for transmitting navigational instructions, there seems to be a lower risk of the receiver misinterpreting the instructions.
- When using a text based mode of communication for transmitting navigational instructions, there seems to be a lower risk of the receiver making his or her own unwarranted assumptions regarding the meaning of the instruction.
- When using a text based mode of communication for transmitting navigational instructions, the need to spend time on repeating the instructions seems to be reduced.
- When using a text based mode of communication for transmitting navigational instructions, there seems to be a decreased tendency for the receiver to respond to the instructions.
- However, when using a text based mode of communication for transmitting navigational instructions, there seems to be an increased tendency for the receiver to ask relevant follow up questions in order to clarify a confusing instruction.

Therefore, when designing a system for shore-based deep sea pilotage, the option of using a text based medium for transferring certain appropriate parts of the information should not be overlooked. However, the choice between verbal *or* written instructions is a false dichotomy, and the optimal solution might very well be a hybrid system where both verbal *and* written information is transferred.

6.2 Further research

This study was conducted with a rather limited sample. It would be interesting to perform further research with a broader sample, including a wider range of nationalities and ages, more representative of the actual population of navigational officers worldwide.

It might also be interesting to conduct research on integrating the two modes of communication in order to draw benefits from the best aspects of each mode of communication.

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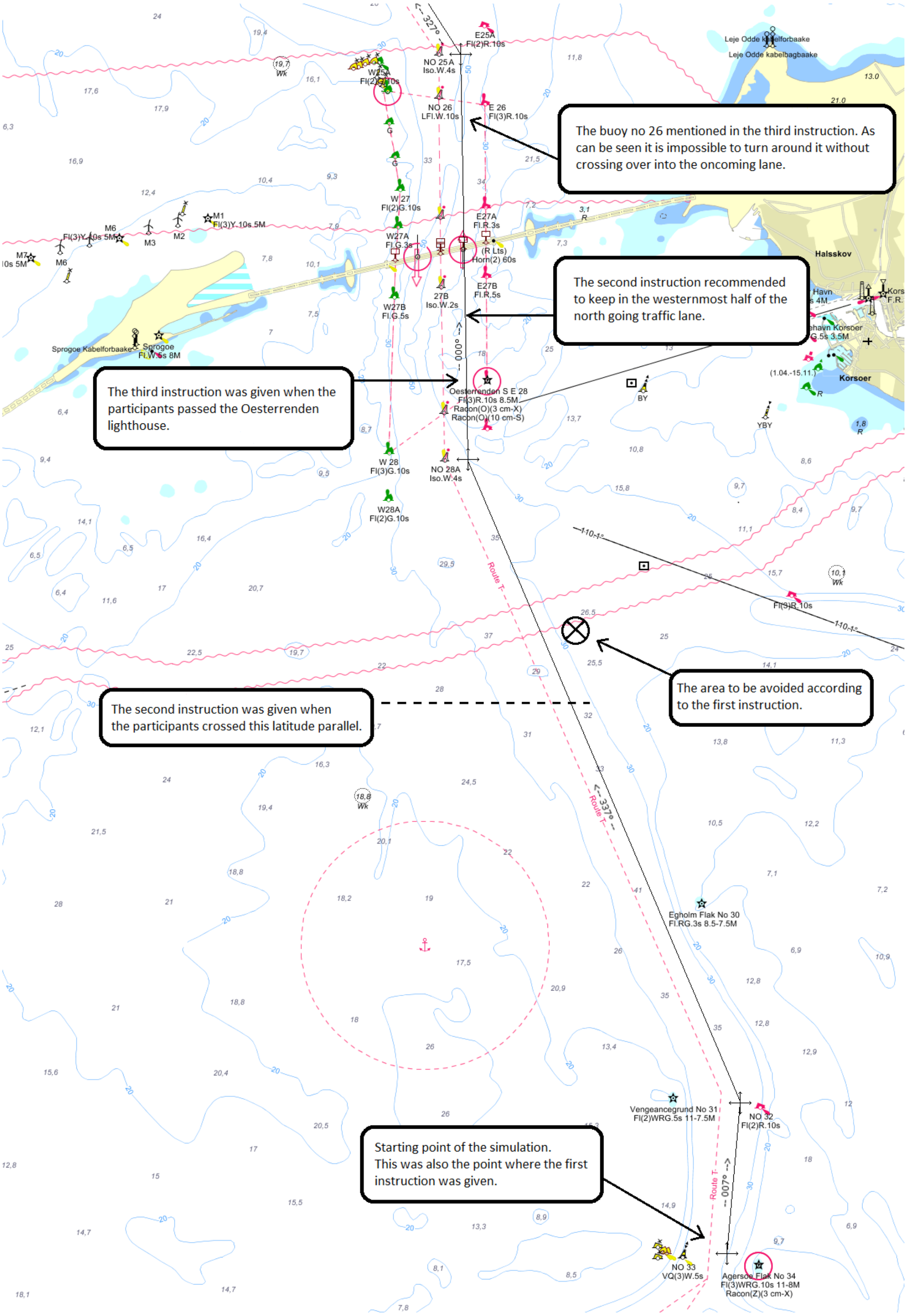
Appendix 1 – Overview of voyage plan and instructions



(Krak, 2013)

Appendix 2 – Letter of Consent

Letter of Consent

- ☐ I, the signee, have the right to choose not to respond to any or all of the questions asked to me during the simulation or the following debriefing.
- ☐ I, the signee, have the right to abort my participation of this simulation or the following debriefing at any time without the need to state a reason.
- ☐ I, the signee, consent to being observed and filmed during the simulation and the following debriefing.
- ☐ I, the signee, consent to having my communication during the simulation – be it text based or voice based – being recorded, saved and analysed.
- ☐ I, the signee, consent to pictures of me taken during the simulation being used in the diploma thesis being written by Peter Eklund and Henrik Göransson and/or the presentation of said thesis.

Place and date

………………………………………………………………………………………

Signature

………………………………………………………………………………………

Name spelled out

………………………………………………………………………………………