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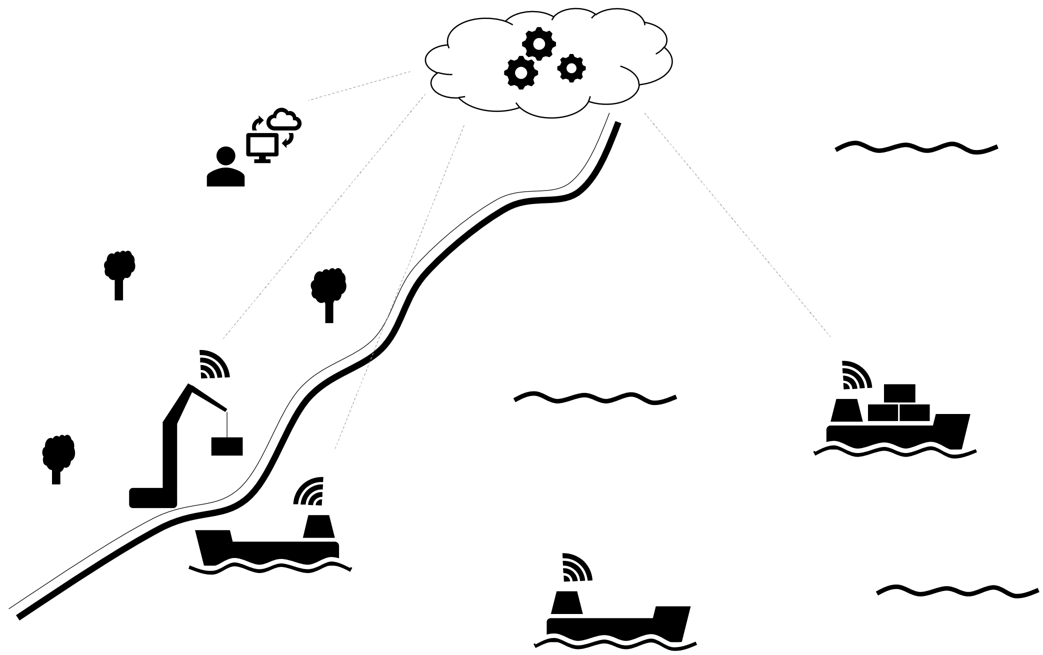

Sea Traffic Management (STM) in the Vessel Traffic Service (VTS)

From the Vessel Traffic Service Operators' perspective

Bachelor's thesis in Master Mariner Program

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Department of Mechanics and Maritime Sciences
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2019

BACHELOR THESIS 2019:01

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Cover: An illustration of Sea Traffic Management tools and how they connect.
Created by William Flodin

Printing /Department of Mechanics and Maritime Sciences
Gothenburg, Sweden 2019

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Abstract

The digitalization in the shipping industry has during the last decade resulted in different research projects aiming to make the shipping chain more effective and efficient. International Maritime Organization (IMO) has developed a "Strategy Implementation Plan" to help navigate the development in the right direction with demands which the projects are trying to fulfil. One of the projects is Sea Traffic Management (STM) which has developed tools to help assist with decision making and a more efficient way of navigating and planning voyages. The tools are aimed towards the mariners on board but also the operators ashore in the Vessel Traffic Service (VTS).

The aim of this thesis is to get an understanding of what the Vessel Traffic Service Operators (VTSO) think of the STM tools user interface/friendliness, their benefits, and what potential problems they could produce. The results are supported by answers from a questionnaire collected during full scale simulation testing of the STM services. This helped to gain a brief understanding in their thought of the STM tools and how user friendly the tools are. The results were strengthened by four interviews of VTSOs who participated in the simulation runs and the questionnaire to get a deeper understanding of the pros and cons on the STM tools. The result indicated that the tools were over-all user friendly and was to a benefit for the VTSOs with increased foresight and overview.

Keywords: VTS, VTSO, IMO, user friendliness, shipping, STM, Sea Traffic Management

Acknowledgements

We would like to dedicate a special thanks to our supervisors - probably the best ones at Chalmers, Monica Lundh and Katie Aylward, without you two this would not be possible. Your knowledge, clever ideas and motivation was the key to this report. A big thank you to Anders Johannesson for helping set up interviews and for sharing your knowledge about the VTS. Of course, thanks to everyone willing to be interviewed. Also, a big thanks to the Librarians for your willingness to assist and help to achieve this. Additionally, we want to thank our lovely friends and family especially Carl Olafsson, Frans Wiktorsson and Olle Elander, your cheering has meant the world. Lastly, thanks to William for the lovely support with astonishing formatting skills.

Phlip Johansson & Teodor Flodin, Gothenburg, February 2019

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Nomenclature

Abbreviations

AIS	Automatic Identification System
ECDIS	Electronic Chart Display and Information System
EMSN	European Maritime Simulation Network
IMO	International Maritime Organisation
SIP	Strategy Implementation Plan
SOLAS	Safety of Life at Sea
STM	Sea Traffic Management
VHF	Very High Frequency
VTS	Vessel Traffic Services
VTSO	Vessel Traffic Service Operator

1 Introduction

The world commerce has for centuries needed an efficient shipping industry and the increasing trade has set pressure for shipping to have safer navigation and higher efficiency (IALA, 2016). In 1948 vessels started to navigate into harbours through restricted visibility assisted by personnel on shore. In the 1960's and 1970's several ship accidents occurred, and the public mass got knowledge about how it could harm the environment. According to IALA (2016), this set additional pressure for a safer shipping and in 1985 International Maritime Organisation (IMO) adopted resolution A.578 'Guidelines for Vessel Traffic Service'. This described a detailed plan about how to set up and plan for a Vessel Traffic Service (VTS) within ports and approaches to achieve safer and more efficient shipping with the main purpose being to oversee the vessels and supply with navigational information. Further, IALA (2016) also states that today's shipping with larger and less manoeuvrable vessels in congested waters carrying hazardous cargoes, is putting the environment at risk and establishing a VTS contributes to increased safety and efficiency.

The shipping industry has during the last decades gone through major technical developments. The operation of the vessel has been affected and there has been a shift from analogous equipment to digital, parts of the task's seafarers used to perform is now automated. With regards to the work on the bridge and the navigation, electronic charts and conning displays is introduced (IMO, n.d.). This drift towards digitalization and the changes in task performance and demands on the crew, has led to IMO developing supporting documents (IMO, 2015). In 1990 IMO established a regulation in Safety of Life at Sea (SOLAS) chapter V to allow navigation with Electronic Chart Display and Information System (ECDIS) (IMO, n.d.). According to IMO the overall goal is to improve the safety at sea, however in this fast-phased industrialization they realized that the shipping could be hampered due to the lack of standardization (IMO, 2015). Furthermore, in 2014 Maritime Safety Committee approved an implementation plan "The Strategy Implementation Plan" (SIP) made by IMO to implement e-Navigation solutions into the shipping (IMO, n.d.). The SIP contained demands put on the implementation of e-navigation.

This resulted in several European Union research projects developing new system and tools to help navigation and optimization both on ships and shore units. Some projects that was started were ACCSEAS and EfficienSea 1 and 2, later came Mona Lisa which put focus on testing new tools. As an outcome from Mona Lisa, Sea Traffic Management (STM) was founded, this project aimed to facilitate the navigation onboard and enhance the communication. STM offers a variety of tools to help ships and shore units with e.g. optimizing routes, route sharing with other ships, port call synchronization, winter navigation. One part of this project was also to assess how work at the VTS center will change with the implementation of the STM tools. This report will investigate how the work in the VTS could benefit from these tools and what the personnel think of the user friendliness and usability.

1.1 Purpose

The main purpose of this report is to investigate how the VTS operators view the STM tools user-friendliness and what advantages and disadvantages they could present, based on their experiences with the tools during simulated test runs, and their general knowledge about STM.

1.2 Research questions

Two research questions have been formulated for the thesis, that are aimed to be answered, and are stated as following:

1. From the VTS operators´ perspective, how user-friendly are the STM tools?
2. What advantages and disadvantages do the VTS operators think the STM tools have?

1.3 Delimitations

The STM tools are newly developed services, meaning a very limited amount of VTS operators have used and evaluated them. Therefore, this study has a relatively small sample size that is limited to VTS operators who have experience and feedback related to the tools. This research was collected by the STM research team, prior to the development of this thesis. Therefore, the authors were not involved in the data collection of the questionnaire data from the simulation runs. The authors of this paper therefore conducted the follow up interviews to fully immerse themselves in the research questions.

2

Background

During 1990, the first versions of electronic chart was implemented as a first step to a more digitized shipping industry according to IMO (n.d.). The organization thus recognized the necessity to equip ships and shore units concerning safety of shipping with modern tools, optimized to enhance maritime navigation, communications and decision making (IMO, 2015). IMO predicted that without any coordination the development of technology could with lack of standardization prevent the progress of future navigation systems on board ships and shore units. The IMO then developed a strategy plan "The e-navigation Strategy Implementation Plan (SIP)" to set demands on the advance of shipping technology and digitalization. The SIP contains several main goals where three of them have an impact on the VTS.

These goals focus on;

- Efficiency of the marine information transfer between the concerned users e.g. ship-to-ship, ship-to-shore, shore-to-shore. The demands of IMO intend to facilitate the vessel traffic observations for shore-based facilities including VTS.
- Facilitate the communication between different parts such as ship-ship and ship-shore, including, data exchange.
- Integrate and present information, on board and on shore to maximize and benefit the navigational safety, but also to benefit the workload of the users through a human-machine interface (IMO, 2015).

2.1 Vessel Traffic Service (VTS)

The world commerce has for centuries needed an efficient shipping industry and the increasingly trade has set pressure to the shipping for safer navigation and higher efficiency according to IALA (2016). The manual also says that this pressure has made authorities around the world to provide aids to navigate around their coastal waters started with shore side beacons and lights. After the World War II the navigational aids of that age were no longer sufficient to take advantage of the full capacity of the port facilities writes IALA (2016). They mean that specifically in poor visibility conditions vessels were delayed which caused further delays and complications throughout the entire transport chain both onshore and at sea. Traffic monitoring using shore-based radar in combination with VHF-communication were implemented to enhance the safety and efficiency. In 1948, Douglas, Isle of Man were the first port to establish a radar-based Port station according to IALA (2016). It is also written that in the 1950's the approaches and port areas of Rotterdam and Amsterdam had established their own shore-based Radar sites.

Today the VTS seems a bit different but has maintained the purpose to inform incoming and outgoing vessels about current traffic inside the VTS area, and other information that could help the vessels with their navigation in or out of the area. The VTS area are often located in congested waters with a high traffic density. The person in the VTS center, who is actively monitoring the VTS area is called Vessel Traffic Service Operator (VTSO). This is the key person within the VTS centre (IALA, 2016). The main task for the VTSO is to monitor either the whole area or a sector of the VTS area depending on size and traffic density, to support the safety and fluency of the traffic. IALA (2016) also states that the VTSO monitoring an area needs to interact in different situations to improve the safety of the traffic flow. Further, the VTSO can use different types of equipment to monitor and interact with traffic, e.g. radar, AIS and VHF-radio. The VTSO provides a variation of services and if an accident occurs or during emergency operations the VTSO can have responsibility to act and coordinate traffic and communications while at the same time maintaining a log of the situation (IALA, 2016).

The VTS are divided in different service levels all aiming to support the vessels within the VTS area. The VTS have different types of services depending on what need a specific area have. There are three different types of services within a VTS, Information Service, Traffic Organization Service and Navigational Assistance Service.

2.2 Communication in shipping

Communication between vessels and vessel to VTS is a key for the operators both on board the vessels and onshore to get an understanding of the current traffic situation. An operator working in the VTS need to have a clear vision of the traffic flow in the VTS area to be able in advance locate any danger or close situations between the vessels in the area. To have situational awareness, different tools such as VHF-radio, AIS, radar and weather forecasts help the VTSO to receive the inputs needed (IALA, 2016). The main tool to be used is the VHF-radio, with this tool the vessels and the VTS can converse to give each other input of the current situation so everyone understands where every vessel is located and what to be expected.

In a research made by Seafarers International Research Centre Acejo et al. (2018) found that the third most identified cause of accidents was failure in communication. The cause of the failure is hard to identify, sometimes it is due to hierarchical structure or language restrictions and sometimes it is simply because information is not passed on (Acejo et al., 2018).

Brödje (2012) describes that communication between vessels and the VTS can vary depending on different factors, there among trust, pattern recognition and protocol. The factor trust implies that the VTSO refrain from informing the navigator in trust, that the navigator already has an understanding of what is going on in the fairway without any confirmation that the navigator actually does. The VTSO sometimes hold back information when they recognise patterns in regard of vessel movements in fairway and/or when patterns are recognised concerning communication between vessel to vessel or vessel to VTS. Brödje (2012) also mentions that protocol is information that always get communicated because it is bound to regulation and therefore cannot be excluded from communication in the VTS system. This is being illustrated in Figure 2.1.

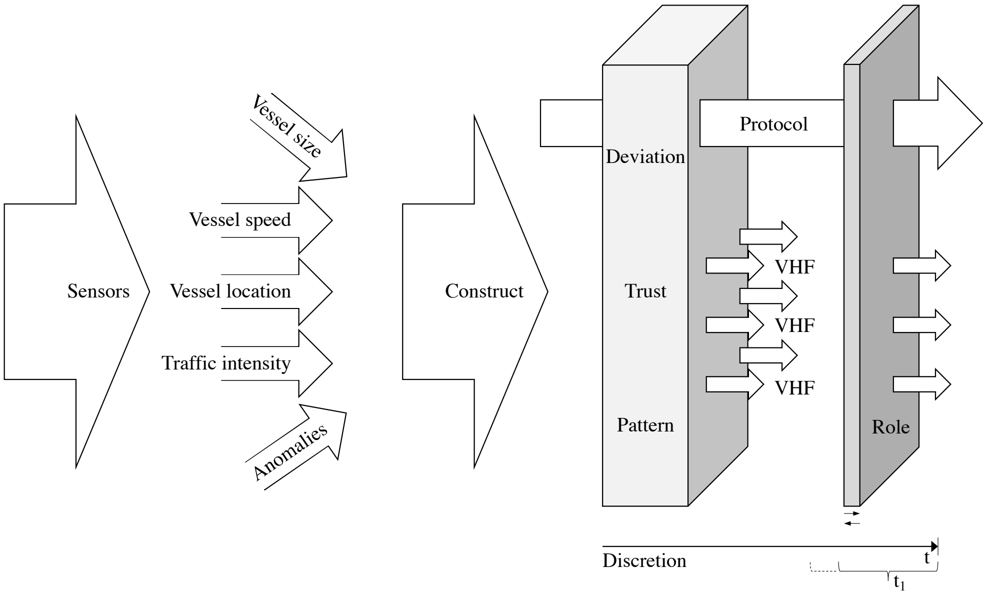

Figure 2.1: The figure illustrates filters of the VTSOs information sharing process, what information the VTSOs decides to share and not. Information received from the sensor gets filtered by the VTSOs thus sometimes refrain sharing. Adapted with permission from Brödje (2013).

Communication between vessels and VTS can also vary depending on how many vessels that are in the area, current traffic situations and weather conditions (De Vries, 2017). During foggy weather, ships tend to slow down, increase the spacing between each other and the communication between vessels and VTS increases which will put on more workload for the VTSO. The variability is something the VTS need to adapt to, every situation is unique, sometimes the situations are easy and sometimes they are more difficult. Further De Vries (2017) implies that the variability needs to be manageable, if the communications increase drastically and the workload becomes overwhelming, the communications can be less effective and less efficient.

2.3 Previous research projects

To develop the e-Navigation and the tools for better communication, several research projects have been carried through, there amongst ACCSEAS, EfficienSea 1 and 2, Monalisa 1 and 2 which later resulted in the development of STM.

ACCSEAS
One of the first project to carry out was ACCSEAS, which purpose was to implement a test bed for e-navigation in the North Sea (ACCSEAS, n.d.). Important results came to be an establishment of a regional platform, provided technology, policies, regulations and standards for an improved access in the North Sea. In ACCSEAS simulation test runs, the importance of getting information in time was discovered. That would help the mariners and shore-based units to get an understanding of the near future surrounding in a clear way (Billesø, 2015).

EfficieanSea and EfficieanSea2
EfficieanSea was a project between different European countries which started after the implementation of SIP (EfficienSea, 2011). The goal with the project was to connect all maritime functions to a central information cloud online. This to be used by the ships to enhance the maritime safety and environment in the Baltic Sea through smart solutions with e.g. new communication channels between ship to ship and ship to coast stations.

EfficieanSea led to the sequel EfficieanSea2, which purpose was to implement what EfficieanSea started. One of the sought was to implement the VHF Data Exchange System, a system where data quick and cheap could communicate between ship to ship and ship to coast station over VHF radio channels (EfficienSea2, n.d.).

Mona Lisa and Mona Lisa 2.0
The first Monalisa project started 2010 where route planning and route sharing was introduced as a precursor to STM. The work of Monalisa continued of a development of a global maritime data sharing function called “Maritime Cloud” and production of electronic certificate for maritime officers on board (MonaLisa, 2008).

A follow up was made on Monalisa called Monalisa 2.0 which defined the goal of STM concept to imply smart solution for the more complex transport chain. STM has developed a quantity of different tools for making shipping more efficient such as route optimization, route exchange between ships, winter navigation and enhanced surveillance in ports (STM, n.d.). The outcome from this project from a shore perspective was positive but one concern was raised after a simulation test run, that workload could increase when tools were applied to several vessels in an area with high traffic density or in emergency situations (Porathe et al., 2014).

2.4 STM and their tools for VTS

The development of STM were made in two previous projects, Mona Lisa and Mona Lisa 2.0. The STM project has developed e-navigation solutions for both ships and shore to improve information exchange, communication, and promote safety and efficiency. The STM project has developed a number of tools which are used by the VTSO including; Ship-to-shore Route Exchange, Chat Function, Route Cross Check, Route Suggestions, Route Based Prediction Tool, Enhanced Monitoring, Shore Based Navigational Assistance and a Navigational Warning Automated Service. These tools of communication has been tested in full scale simulation using European Maritime Simulation Network (EMSN). This simulation network include 13 simulation centres in seven different European countries that can run simulations with up to 37 bridges connected at the same time (Burmeister et al., 2016).

The tools mentioned above are defined below and will hereby be referred to as the "STM tools" or "STM services".

Ship-to-Shore Route Exchange
This service allows vessels to broadcast the next seven waypoints of their intended route (Aylward et al., 2018). Route segments are broadcasted through Automatic Identification System (AIS) and give additional information to the presently available data obtained by radar/ARPA and AIS. Ship-to-shore route exchange allows the VTSO to receive the monitored route of STM enabled vessels in the vicinity and have an overview of their intentions according to Aylward et al. (2018). In real time, the VTSO will be able to see if the vessel is sailing on the planned route or heading towards possible danger.

Chat Function
The chat function is a standalone software (e.g. Skype) which is integrated into the ECDIS on board and at the VTS station on shore writes Aylward et al. (2018). The chat function offers text communication between the VTSO with STM enabled ships. It allows the VTSO and the ship to communicate through other means than VHF. It allows both parties to review previous agreements with a goal to reduce the misunderstandings commonly experienced over VHF (Aylward et al., 2018).

Route Cross Check
According to Aylward et al. (2018) a VTS centre can receive any planned route and cross check such route against any navigational dangers and if necessary, send a route suggestion back to the ship.

Sending Route Suggestions
This service allows the shore-centre to send a suggested route to the ship, to be reviewed by the bridge team and then either accepted or rejected (Aylward et al., 2018). Further Aylward et al. (2018) writes that this service can be used in various situations, for example if several vessels are warned to avoid a certain area, the shore centre can plan a route based on all available information and directly send this route to the vessel.

Enhanced Monitoring
This tool is only for the VTSO, it does not require any action from the personnel on board other than broadcasting their route to the VTS according Aylward et al. (2018). After having received a ship's monitored route and schedule, shore centres will be able to detect if planned schedule is not kept or if ship deviates from monitored route. This service alarms the VTS when a vessel is diverting from their route which will make the VTSO aware of the situation and can contact the ship in question.

Route Based Prediction Tool
This tool shows where two ships will meet if they are following their intended route. This allows the VTSO to have an enhanced overview of upcoming situations and the opportunity to intervene at an earlier stage in a potential close-quarters situation (Aylward et al., 2018).

Navigational Warnings
This service allows the shore centre to send a notification which overlays a Navigational Warning Message directly on the ECDIS. If the Navigational Warning involves a geographical area to avoid or be aware of, this will be automatically plotted onto the ECDIS, so it is visible to the bridge team (Aylward et al., 2018).

3 Methodology

A good way to retrieve accurate results is to use both quantitative and qualitative methods. First through the quantitative data to pick up interesting observations and to later use in the collection of the qualitative data to get a deeper understanding (Eliasson, 2010). The thesis used a questionnaire as a method to collect quantitative data and provided the basis for the interviews which included a qualitative data collection.

3.1 Literature review

For a better understanding of the background connected to the research questions a thorough information gathering had been done. The information gathering started with understanding the STM project and their tools, this was carried through by reading on their website and the precursors research leading to the founding of STM. When a greater understanding of the STM was established, a more detailed information connected to our research questions was gathered by searching on Chalmers internet-based library, searching for keywords like “VTS”, “VTS Operators”, “VTS Operations”, “E-navigation”. More information covering different aspects of VTS and their work was collected from previous theses.

3.2 Collection of quantitative data

To get a better overall understanding on what the VTSOs thought about the tools, quantitative data was acquired from a data-set collected by the help of a questionnaire that followed after a STM tool evaluation run in the EMSN, where two scenarios were performed. The scenarios tested in the EMSN are described in 3.2.1 as well as the experimental design.

3.2.1 Scenarios and Experimental Design

Scenarios

In order to test the STM services, subject matter experts developed two simulator scenarios, one in the South Western Baltic and another in the English Channel/-Southampton. The scenarios were strategically designed to test the different functionalities of the STM Services. The Baltic Scenario tested the use of the STM services in dense, close quarters traffic situations whereas the English Channel scenario was generally less busy. Each geographical area also had a respective “shore center”, one located in Southampton, UK and the other in Gothenburg, Sweden.

The “shore center” functioned as a typical VTS center with additional access to the STM services and was the point of interest for this study.

Experimental Design
Data were collected in the EMSN over eight days during two non-consecutive weeks in 2018. The EMSN included nine simulation centres, 30 ship bridges, and the two VTS centres in Gothenburg and Southampton. Both VTS centres held a briefing session at the beginning of the day for the VTSOs which consisted of information about the STM/EMSN, the purpose of the STM services, schedule for the day, and an opportunity to ask questions.

The briefing was followed by a 1.5-hour familiarization session in which the VTS Operators had the opportunity to communicate with vessels and practice using the services. Once the familiarization session was complete, the first exercise began and lasted for 1.5 hours. The first exercise was always the English Channel Scenario as it was designed to be less busy and provided the VTSOs time to explore the usage of the STM services.

Once the test day was concluded, the VTSOs completed a “post-scenario questionnaire” which asked questions about their experiences with the STM services (i.e. usability, workload, user-friendliness, appropriate information, workload, etc.). The results from the post-scenario questionnaire are analysed in chapter 4 and discussed in chapter 5.

3.3 Collection of qualitative data

To get more detailed information, qualitative data was gathered through four, 30-40 minutes interview sessions with the VTSOs involved in the EMSN simulation test runs. The purpose of using interviews as a method was to get an understanding in what the VTSO thought about the STM tools which is essential in order to answer the research questions. The interviews were semi structured following an interview guide with allowance of follow-up questions. The questions in the interview guide were chosen out of the answers given from the questionnaire and additional questions to help answer the research questions. The interviews were recorded and later transcribed to be sure no details were missed. Before the interviews started the participant filled in a consent form which indicated that the interviews were being recorded and used in the research. The structure of the interview was divided into eight sections, where seven of the sections were focusing respectively on different STM tools with the same questions and the last one was an overall section which covered all tools.

For each tool these questions were asked:
- What is your general thought of this tool?
- What aspects do you think is good?
- What aspects do you thinks is bad?

- Do you think this tool would lead to a safer traffic flow within the VTS area? if so, why?
- Do you think the tool affect the workload? How? Why?
- How will this tool ease for you as an operator?

For the overall section, the main thought was to get the operators to highlight a tool they thought was better and one that was the worse. For this section these questions were asked:

- What is your general though of the EMSN simulator runs?
- Which of these tools would you say helped you the most? Why?
- Which tool would you use the most? Why?
- Do you think any of the tools seem like too much or unnecessarily?
- If you would be offered to use their tools, would you use all? if not, which would you use?

The questions were sometimes followed by a follow up question depending on what they answered, typical follow up questions was, “why?” and “how?”.

Thematic analysis

To analyse the interviews Thematic Analysis was used. This method of analysis is based on identifying themes within the qualitative data (Braun & Clarke, 2006). Basically, this method involves six steps, where the first step is to familiarize with the data. This involves transcribing and reading and re-reading the entire data and make notes of initial ideas. Step number two imply to code the data-set and collate relevant data to each code. In step three, the codes are collated into themes. Later in step four, a review of the themes is made to see if they are applicable to the whole data-set. Step five is being described by Braun & Clarke (2006) as an ongoing analysis to specify every theme and also name them. Lastly, step six which the concluding chance for analysis is where a selection of themes is made, it is in this step the analysis is written in the report in trying to connect to the research questions and the purpose of the thesis (Braun & Clarke, 2006).

4 Results

The main result of this project found that the tools of STM is positively perceived by the VTSOs both in terms of usability and operationally. With help of the STM tools the operator gets a foresight in the traffic and also receives the ability to plan and oversee the situations in a new way. The questionnaire showed slightly lower evaluations for the “Enhanced Monitoring” tool, which is supported by the interviews which provided insight into why this was the case.

In the results chapter, section 4.2 and section 4.3 intend to answer each research question respectively based on the results from the data collection.

4.1 Demographic of data collection

Based on the questionnaires and interviews, a demographic analysis was performed which resulted in the following demographics.

Demographic of questionnaire results
A total of 16 different VTSOs, 13 (81%) men and 3 (19%) women participated in the EMSN STM simulations. Eight VTS Operators were from Sweden, six from the UK and two from Norway. The participants were between 20 and 69 years of age. Years of experience as a VTSOs ranged from <1 year, to 11-20 years, with most VTSOs having between 3-5 years of experience. The current role of the VTSOs varied, nine participants currently work as VTS Managers, Operators, or Supervisors, three work as pilots, two as instructors, one as a project leader, and one as a captain.

Demographic of interview results
The interviews were performed on four different VTSOs all (100%) of them were men from Sweden who participated in the EMSN STM simulation. Two (50%) were between 40 and 49 years of age and the other two (50%) were between 60-69 years of age. The range of VTSO working experience ranged from 1-2 years, to 11-20 years divided in 1-2, 3-5, 6-10 and 11-20 years of experience, with 100% of the participants at the moment having VTS operator as their current occupancy.

4.2 Results from the questionnaire

The first research question, stated as: *"From the VTSOs´ perspective, how user-friendly are the STM tools?"*, will be answered by using results from two different sections of the used questionnaire. These are analyzed from two perspectives; usability and user-friendliness.

4.2.1 User-friendliness

In this section the VTSOs were asked to rate the STM tools regarding their user friendliness, on a scale 1-7 where 1 = Worst imaginable, 4 = Fair and 7 = Best imaginable. The values presented in Figure 4.1 are the mean values of each answer on all the questions. The standard deviations have been added in order to see the spread among the answers.

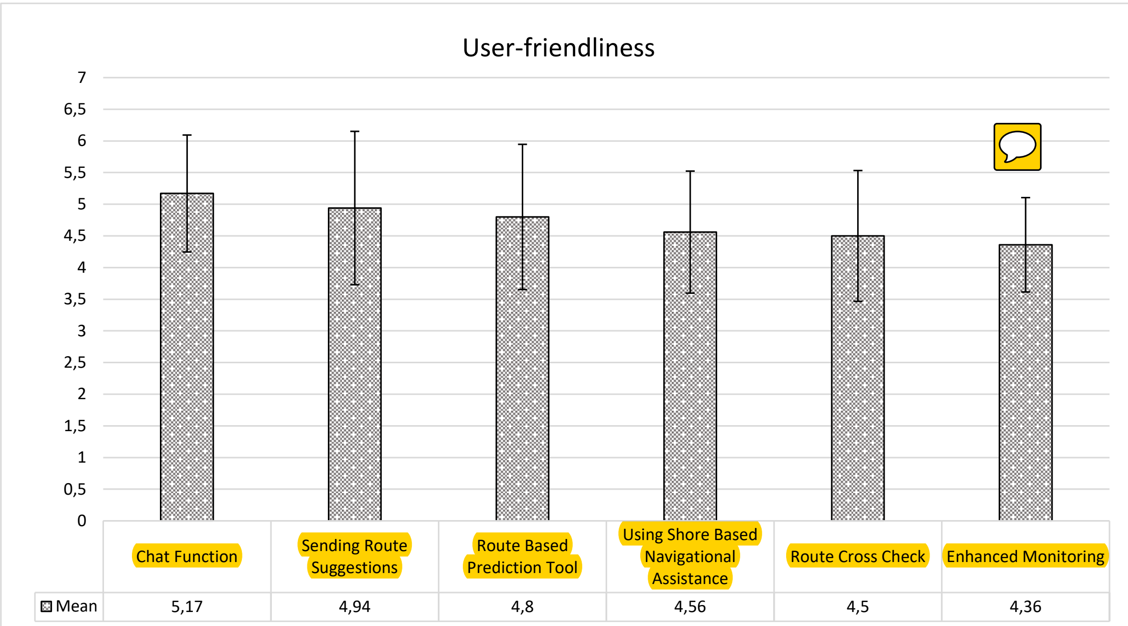

Figure 4.1: The mean value of all the answers from the “User-friendliness” Section.

4.2.2 Usability

In this section of the questionnaire the VTSOs were asked to in which extent they agree on the usability perceptions stated in Figure 4.2-4.8. The scale is from 1 to 5, where 1 is strongly disagree, 3 is neutral and 5 is strongly agree. The value presented is the mean value of all the answers and the standard deviation to see the spread among the answers. For example, in Figure 4.3, “Easy to use” got a mean value of 4.32, which would translate into agree/strongly agree.

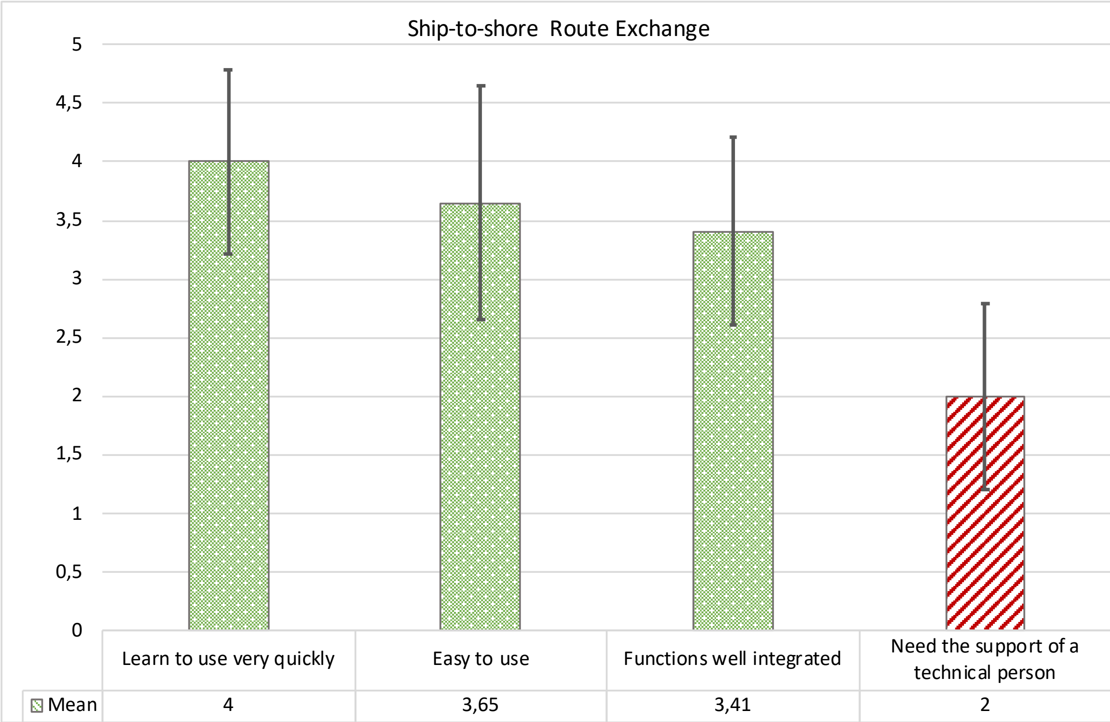

Figure 4.2: This shows the result of the tool "Ship to Shore Route Exchange". The dotted bars illustrate a statement that is positive for user friendliness and the diagonal lined bars for statement that is negative for user friendliness.

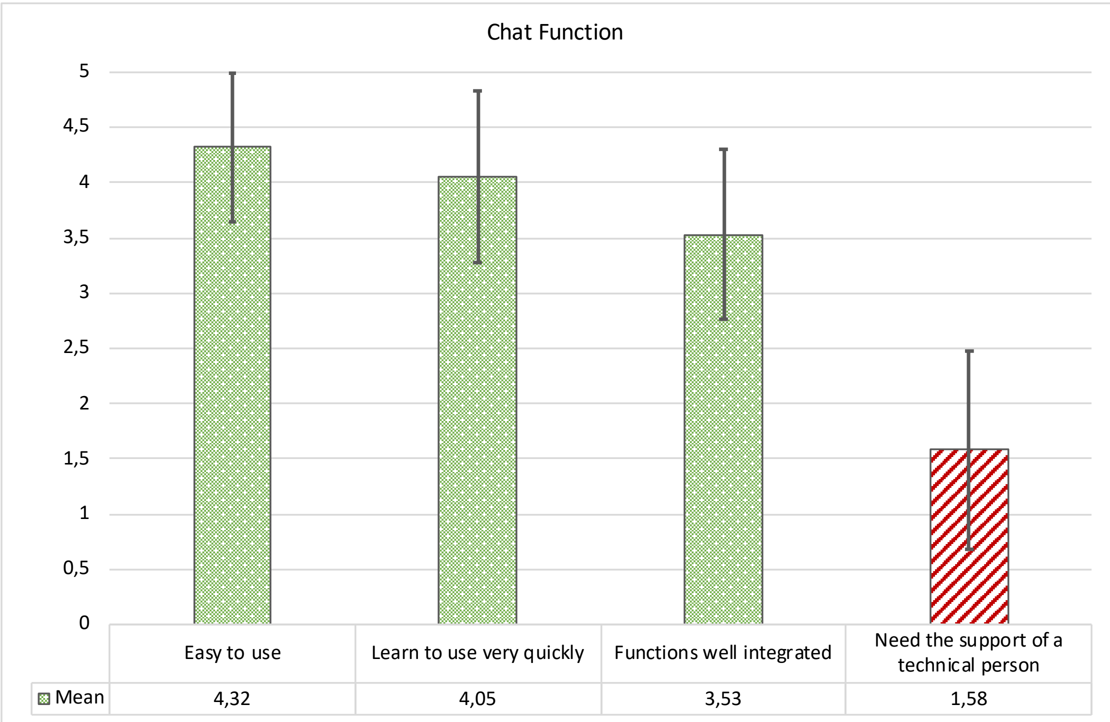

Figure 4.3: Shows result of the "Chat Function". The dotted bars illustrate a statement that is positive for user friendliness and the diagonal lined bars for statement that is negative for user friendliness.

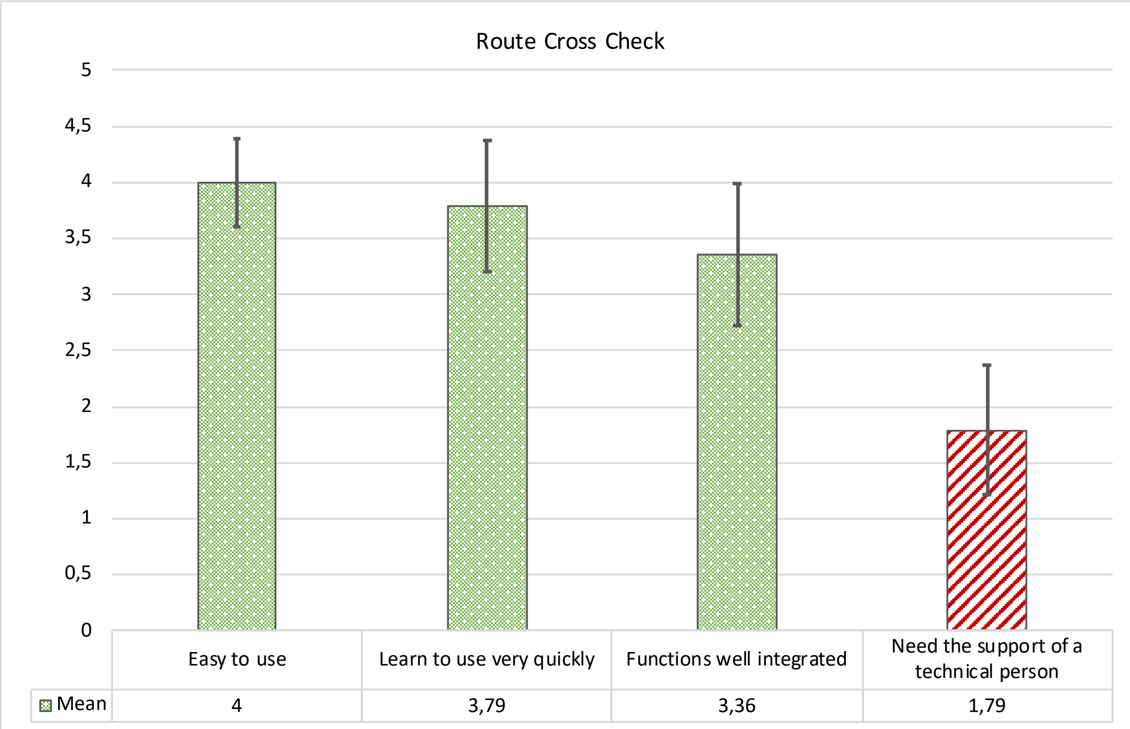

Figure 4.4: Shows result of the "Route Cross Check". The dotted bars illustrate a statement that is positive for user friendliness and the diagonal lined bars for statement that is negative for user friendliness.

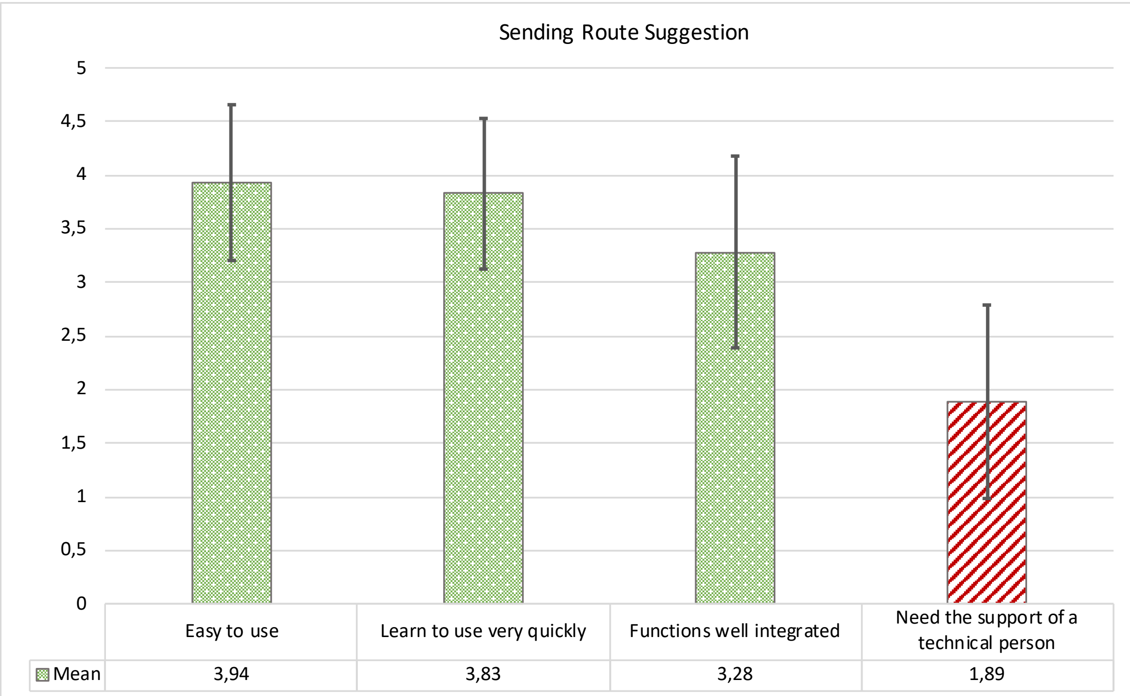

Figure 4.5: Shows result of the "Sending Route Suggestion". The dotted bars illustrate a statement that is positive for user friendliness and the diagonal lined bars for statement that is negative for user friendliness.

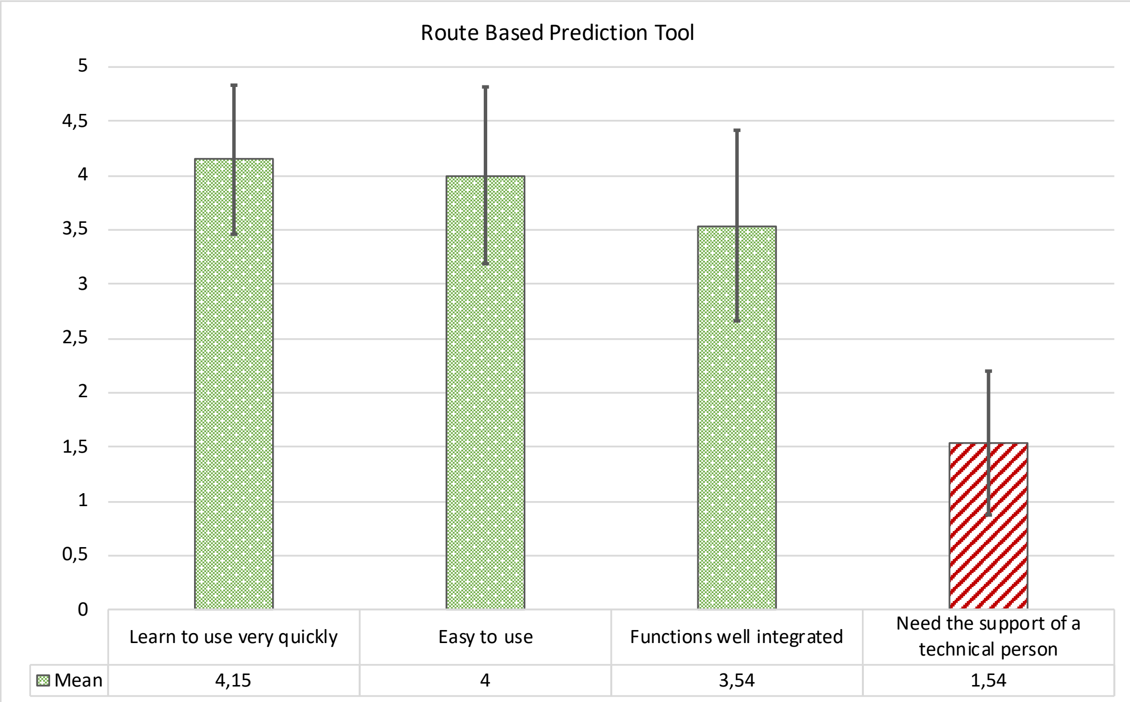

Figure 4.6: Shows result of the "Route Based Prediction Tool". The dotted bars illustrate a statement that is positive for user friendliness and the diagonal lined bars for statement that is negative for user friendliness.

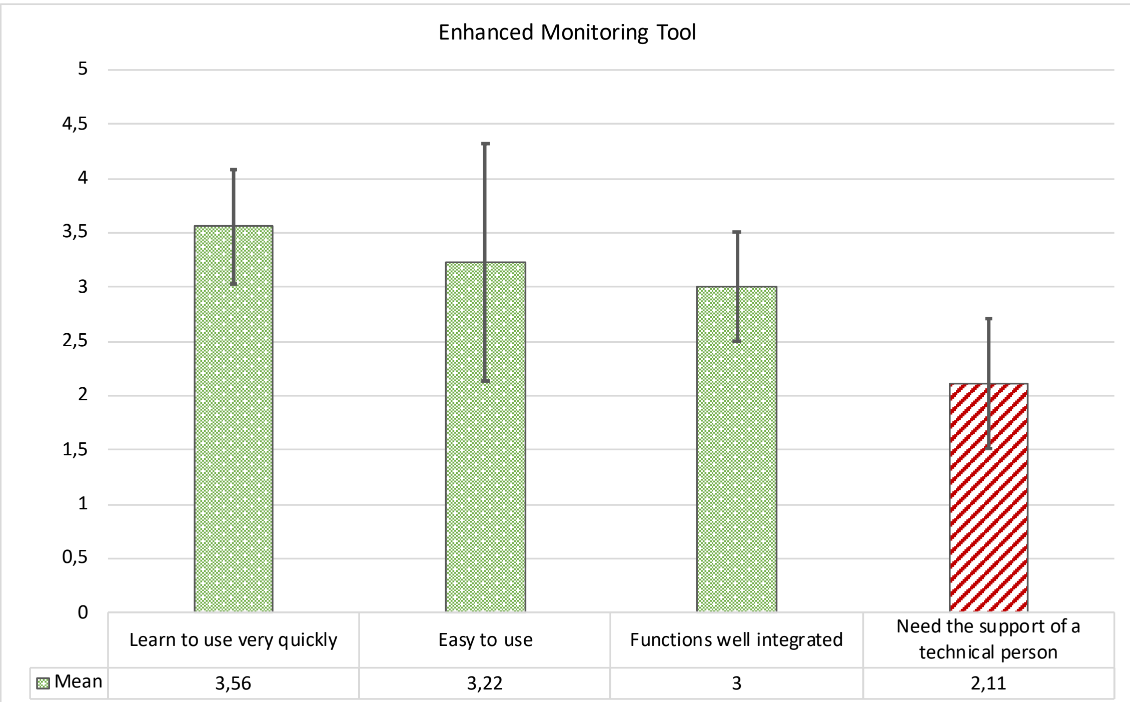

Figure 4.7: Shows result of the "Enhanced Monitoring Tool". The dotted bars illustrate a statement that is positive for user friendliness and the diagonal lined bars for statement that is negative for user friendliness.

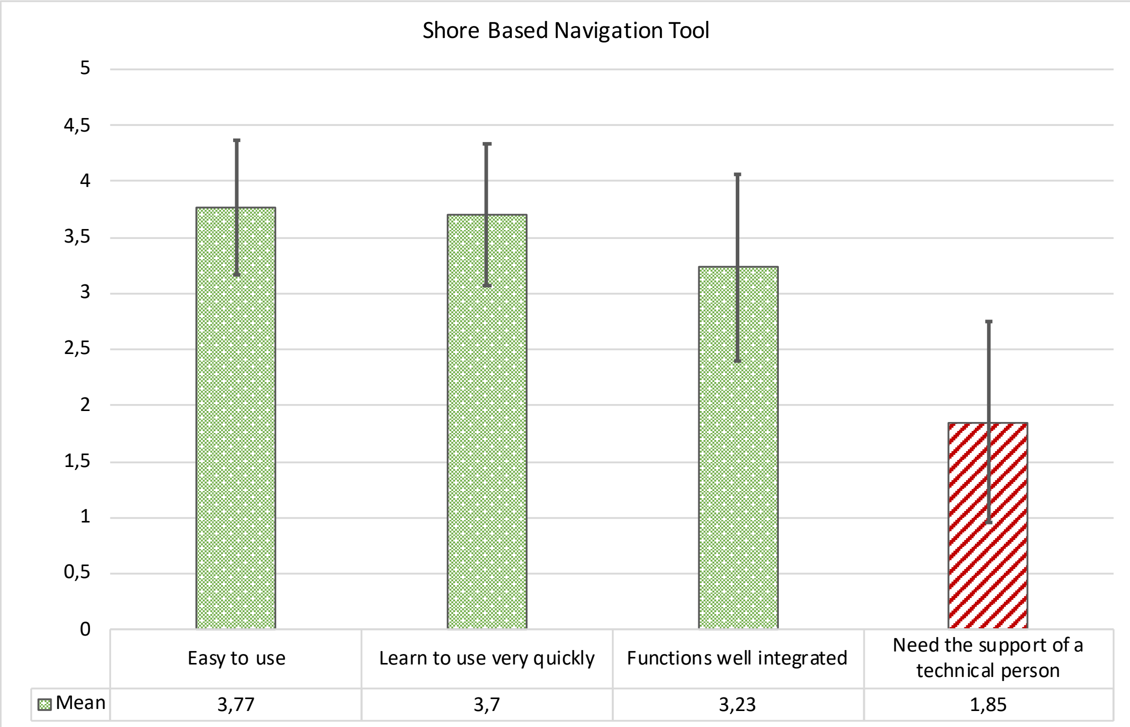

Figure 4.8: Shows result of the "Shore Based Navigation Tool". The dotted bars illustrate a statement that is positive for user friendliness and the diagonal lined bars for statement that is negative for user friendliness.

4.3 Results from the interviews

The second research question aims at answering the questions *"What advantages and disadvantages do the VTSOs think the STM tools have?"*. During the analysis, two main themes and four sub themes were discovered which are shown in Table 4.1 below and will be expanded upon within the sub-sections below.

Table 4.1: An overview of the two main themes and the four sub themes that were distinguished in the analysis.

Main Themes	**Sub-themes**
4.2.1 Foresight	4.2.1.1 Overview 4.2.1.2 Less verbal communication
4.2.2 Increased workload	4.2.2.1 Increased level of alarms 4.2.2.2 Too much information

The difference between foresight and overview might be vague, but in this report, foresight focuses more on the ability to plan for the VTSO itself in advance. Overview is more the ability to see how the vessels planned and what is happening in real time.

Foresight
The key word that was mentioned the most was the importance of foresight, and the ability to in advance see how the in, and outgoing vessels have planned, and also sort of plan it for the operator him/herself. One question about the operators' general thoughts about STM, one person answered that with help from the tools the operator are able to check, change and plan for a later stage.

> *"It's a lot of ups and downs in the traffic density, so now in the morning I would not be able to change or check any routes, but now when the traffic got less, you can sit down and check routes and maybe suggest some changes to it, so when the next rush comes you have prepared it."*

Another thing that was mentioned was that the traffic gets more controlled and the number of unexpected events decrease. A contributing tool in this case was meant to be "Route Cross Check" a tool letting the VTSO validate a planned route in an early stage. One operator said that you get knowledge in before of how someone has planned, and you can expect more predictability.

> *"You get a sort of predictability of how they are supposed to drive, it's not as individual as now, every vessel does not have to make their own route plan in the same way.... if you get your route validated and the route is fairly similar every time, the chance for surprises decrease"*

This participant also meant that this will contribute to the area becoming more controlled, similar to the Traffic Separation System and mentioned the parable with it. Overall the participants found the tools having positive affect to their foresight.

Overview
The tool that had the most positive feedback in both the questionnaire and the interviews was the tool "Route Based Prediction", a tool that shows where two ships will meet if they followed their intended route. This was appreciated by the operators because it would give them a heads up in advance that these ships may head in to close-quarters situation and it would be easier for the operators to understand and act on the situation. A participant in the interviews explained that if you in advance could see where two vessels potentially were going meet it would be easier to do small adjustments early to avoid meeting in critical points.

> *"I could imagine that it would be useful to sometimes see... Out of a VTS-perspective but also for the ships to see where you will meet, especially if it is close to congested waters so that you could adjust the speed to avoid meeting in critical points."*

One operator during the interview started off initially when talking about the tool "Enhanced Monitoring" that it would increase the workload of the operator because the increasing amount of alarms but with the right modification it could improve the overview. He suggested that if you could define an area to where these alarms could be helpful, it would limit the alarms and meanwhile increase the situational awareness and overview.

> *"It could in some cases increase your attention to a situation that you sometimes miss. You could take a problem area where incidents have happened before and aim the tool that it would alarm if they deviate from the route in such a specific area. So, when an alarm sounds it is relevant."*

Less verbal communication

Another recurring theme was the aspect of verbal communication, all of the participants had in common the perception about decreased verbal communication. The main tool contributing to this fact was meant to be the "Ship-to-shore Route Exchange". A common thought about the tool was the idea of less misunderstandings occurs if the VTSO are able to see the intentions of a vessel, this brings the knowledge about which vessels will be involved in different situations.

> *"You were able to see immediately which vessels who were going to be involved, and then you only had to contact the ones involved, then you avoid talking to someone who's not going into the affected area for example"*

One major thing that was mentioned were the facilitated ability to communicate information about a certain position in latitude and longitude, which was often meant to be misunderstood in verbal communication.

> *"The chat function, yes I think this also increase the safety when it comes to misunderstanding and such, it's easier to misunderstand each other verbally, of course it happens in text communication as well, but some information is a lot easier to communicate in text, such as positions or similar"*

To be able to see who is going to be affected by a certain situation and the decreasing misunderstandings would reduce the amount of verbal communication. One operator meant that this implies the verbal communication would then be more important, the VHF will only be used in more important situations or for more important information. Another comment to the "Ship-to-shore Route Exchange" were that it would reduce the radio communication, and it therefore became more of importance.

> *"If you know where a vessel is about to turn it implies less VHF-communication, and less risk of misunderstanding, it would for sure reduce the verbal communication, which then entails the information on the VHF becoming more important"*

The "Chat Function" showed very positive results both in the quantitative data and the quantitative, one explanation from the interviews were that it reduced the verbal communication and it did confluent good with the other tools. According to the participants they mostly used the chat together with other tools such as the “Sending Route Suggestions”, first they suggested a route and then sent a short message to the vessel with an explanation. Reduced verbal communication improved the work of the operators according to all the participants.

4.3.1 Increased workload

In the interviews the topic workload was presented to which different aspects and concerns came up. The main problem the VTSO brought up was the fear of increasing amount of alarms. Another concern that was brought up when mentioning workload was the possibility for giving too much information, i.e. when many routes are presented at the same time, it could be more stressful and increase the amount of time to understand a scenario.

Increased numbers of alarms

The tool with least positive results in the questionnaire was “Enhanced Monitoring” which had an alarm function when a ship deviates from its route. Apparently because the increasing number of alarms was not appreciated by the operators, according to the interviewees. Participants meant it would increase the workload and draw attention from what might be more important.

> *“I think it (enhanced monitoring) would affect the workload negatively, but you don’t get any winnings from it, of course sometime it could get winning out from it, but i think in general it will be an alarm that’s gets muted and won’t get any attention in the end, you want to have an alarm when it’s for real something that can go wrong.”*

This function was perceived to create unnecessary alarms, several participants said that vessels might deviate from their route without being in risk of danger. One meant that in narrow waters there is a lot of obstacles to avoid i.e. fishing vessels, buoys and pleasure boats etc. Therefore, it is not always dangerous if a vessel deviates from their planned route. As said in previous citation, the VTSOs appreciates alarms, but preferably only when it is a serious situation, the other alarms are unnecessary alarms. One perception about too many alarms is that it contributes to neglecting the alarms in the end.

> *“I see a direct risk of increasing amount of alarms and increasing amount of alarm tend to lead to not listen to the alarm at all and only constantly muting them.”*

The VTSOs who got interviewed had a similar function in their VTS center in which on their monitoring screen had highlighted areas in different critical navigation points which they call no-go areas. If a ship would pass that point the system would raise an alarm. The problem they explained about this system was during summertime when sailing vessels and pleasure boats entered the highlighted areas, alarms was constantly triggered, which they thought increased their workload.

> *"That is the problem with our no-go areas, in the summertime we have sailing vessels entering the areas and triggers the alarms... It triggers all the time and at last no one cares and only mute the alarms."*

The common thought about increasing amount of alarm is that it would harm the work of the VTSOs.

Too much information
Another concern about the tools were that the screen might be too information heavy. The interviews showed that the participants were worried that the screen would present too much information. Several operators said that "Ship-to-shore Route Exchange" could create confusion if too many routes were displayed at once or if it was heavy traffic or an emergency situation.

> *"You want to see how they (the vessels) have planned, but I don't want to see it all the time because it will create disturbance, if it's lot of traffic."*

This occasion perceived to occur in more narrow waters heavily trafficked, examples as the Sound and the sound of Gibraltar was brought up. It was meant these areas might easily be too crowded to use the "Ship-to-shore Route Exchange" due to overwhelming information.

> *"I could imagine places like Gibraltar or the Sound, if everyone shows their route it only creates a conglomeration"*

Although this tool was overall appreciated when used in the simulations, the experience of too much information were mostly speculations more than observations therefore the high evaluations on the questionnaire.

5 Discussion

Digitalization and e-navigation are creating challenges for the industry amongst lack of standardization and a need of a more efficient communication. This development has generated a need for research in the area to establish a more efficient way to monitor the traffic and enhance the communication. Other ways to communicate information like route exchange, has been researched in other projects like ACCSEAS (Billesø, 2015) and Mona Lisa 1 and 2 (MonaLisa, 2012). Following the Mona Lisa project, the STM was initiated with the purpose to make the shipping industry safer, more efficient and provide the different parties with efficient ways of communication. The result from the questionnaire included in the STM project indicate that the VTSOs are over-all positive to the STM tools, especially the usability of the "Chat Function", "Sending Route Suggestions" and the "Route-based Prediction Tool".

Further the interviews gave a deeper understanding as to why the VTSOs think their work could benefit from these tools. Elements such as "Foresight and overview" were factors that was considered to be enhanced by the tools. With regards to the results this was said to help the VTSOs ability to plan ahead and in time be able to predict upcoming future situations and thus be given time to act before situations becomes critical. This could also positively affect the workload which results from the Mona Lisa project has raised as a concern saying that the workload could be expected to increase when too much information was presented at the same time (Porathe et al., 2014). The interviews in this study also addressed this as possible problem as the tool "Ship-to-shore Route Exchange" was considered as a potential disturbance for the VTSO if many routes were presented at the same time. Even though this concern was raised during the interviews the tool was popular and seen as an asset in the future work of a VTSO. However, the operators' thoughts about increased workload might be a question about how skilled they were with the tools, if they had more experience with these instruments it might be perceived to positively affect their work.

According to Acejo et al. (2018) communication failure is the third most common reason for accidents, failure can occur because of information is simply not passed on between different parties. Brödje (2012) argues that communication between ship and shore to some extent is filtered. We think this information that is "simply not passed on" can be due to these filters, Brödje explained. He describes that for instance trust, can block the communication, and the sender, in trust believes the receiver already knows the information that is about to be communicated, thus do not pass it on. According to the results of the interviews several participants perceived the tools to enhance the communication due to the reduced verbal information exchange thus reducing the risk of misunderstandings. The tool that was found to contribute the most to decrease the misunderstandings was the “Route Based Prediction Tool”, this perception might be due to these filters were not interfering. The tools of STM could in some respects replace parts of this verbal information that normally gets filtered out like confirming intended route of a ship, the information is presented on a screen instead of communicated over VHF and thus contribute to increase the safety by making the communication more effective. In alignment with these results the “Ship-to-Shore Route Exchange”, “Route based Prediction Tool” and “Chat Function” was also argued to decrease the verbal communication and thus reduce the variation of the amount of communication which De Vries (2017) found as a potential problem. The results of that study gave evidence that shows that the varying amount of communication could increase the workload for the VTSO.

The results of user-friendliness from the questionnaire shows the tool that was least desired was “Enhanced Monitoring”. This was also confirmed and explained in the interviews and the reason was the fear of the increasing amount of alarm that could add to the workload. The participants in the interviews explained that this tool was similar to one of their tools they already use which also had a tendency to give a lot of faulty alarms. The interviews showed that the STM tool “Enhanced Monitoring” could actually decrease the workload. A thought about “Enhanced Monitoring” were that it could, if used in certain way, be contributing to an easier monitoring. One VTSO during the interviews said that if it would be possible to allow alarms from this tool in one or some specific areas within the VTS area it could be beneficial for both the workload and the ability to monitor the traffic.

The results in this thesis shows that the STM tools overall aligns with IMOs SIP. In the user-friendliness section, all the tools showed positive results, but during the interviews the tool “Enhanced Monitoring” produced weaker results due to the potential increase in amount of alarms, which could to some extent increase the workload for the VTSOs. This is the only tool according to our result that contradicts the demands set in IMO’s SIP (IMO, 2015). The results from the interviews and in connection with similar research like Brödje (2012) and De Vries (2017), shows that the tools excluding “Enhanced Monitoring”, benefit the workload for the VTSOs which aligns with IMOs goal to ease the monitoring of the vessels and facilitate the vessels traffic observation for the VTS centres (IMO, 2015).

5.1 Choice of method

Because the target groups were limited a questionnaire was not enough to strengthen the study and another method had to complement the results. Combining methods is a good way to get a more complete picture of the results (Eliasson, 2010). The choice of the mix-method approach in this paper were used to give a comprehensive view of the STM tools directed towards the VTSOs. The questionnaire gave a statistical analysis of how the tools were apprehended and the interviews an explanation of their opinion. Eliasson (2010) writes that to get a measured number on a research e.g. how good something is perceived; quantitative data is to be preferred. Eliasson (2010) also brings up that quantitative data is better to illustrate what a target group in general think in a certain question. This was appropriate for the first question of this study because it could easily be illustrated with numbers and diagrams. Since the authors of this report were not involved in the questionnaire data collection, it was difficult to fully understand the intent of all the questions, and therefore properly interpret the results. It would have been optimal to have been involved from the beginning of the STM project. Some of the questions in the form were a bit vague and the underlying thought of why some questions were phrased in certain ways could be of interest to give more understanding to the results. The result from the quantitative data could vary if the target group had a larger population which might had given a more nuanced result. Another way of collecting the qualitative data could be for example focus groups, but this method is harder to set up logistic wise where everybody has to able to attend at the same time. Using observations to gather qualitative data were unmanageable though the test runs were performed months earlier. Interviews was thought to suit the participators best because of their working hours.

For a research to be reliable, the results of the research should be consistent (Kvale, 1997). In this study it would increase the reliability if more simulation runs with the same or a similar questionnaire would reflect the results collected in this research. This was not possible to achieve but to counter this, interviews was done to support the answers from the questionnaire. The time between the test runs and the interviews could have reduced the reliability, but the quantitative data from the questionnaire is reflected in the qualitative result from the interviews which could be considered to make the results reliable. All of those who were interviewed had been involved in the STM EMSN test runs. The familiarization before these runs was only about 1,5 hours meaning that the knowledge about the tools and their operation was limited, which could reduce the reliability. In the most desirable case, the VTSOs had better knowledge about the tools and the interviews had been performed in connection to the questionnaire. When analysing the data collected from the interviews both authors analysed the data privately for themselves and then later compared the founding, in this case the conclusions were very similar which also is a factor that would increase the reliability. During test runs evaluating tools of MonaLisa project, concerns about increased workload due to too much presented information was raised (Porathe et al., 2014). STM tools similar to the ones of Monalisa raised the same concerns, which would increase the reliability.

The validity in this study would mean that the investigation that was done, actually researched what was supposed to be researched (Eliasson, 2010). This implies that the methods actually relate to the purpose and research questions set for this study. This was accomplished through the questionnaire because the questions were aimed at usability of the tools which fulfills one part of the purpose of this thesis related to user friendliness. The interview guide was constructed together with the questionnaire in order to grasp what questions to ask and what to be extra attentive to. The interviews aim was to cover the purpose of what benefits or problems the tools could have, and in such way the method could be considered valid.

The validity in an interview that would be considered is the reliability of the answers given from the person being interview and the quality of the interview being done (Kvale, 1997). The answers from the VTSOs in the interviews was similar to each other which would indicate that the reliability of the answers was good. More interviews would of course increase the reliability. The quality of the interviews could be discussed, no one of the authors had done interviews before which could if the authors been more experienced give a more qualitative result. To help counter the inexperience an interview guide was made, and the questions was reviewed by a more experienced researcher. The guide was good to keep the interview within subject and to limit the answers to be connected to the purpose of this thesis.

6
Conclusion

The results of the STM tool testing have proven to meet the goals of IMOs SIP with regards to facilitating both the communication and the ability to monitor the vessel traffic, according to the personnel at the VTS center. The interviewed participants had a positive view of the tools and thought it would benefit their future workplace with increased foresight and a better ability to overview the VTS area. The questionnaire found the STM tools to be user-friendly with a slight difference between each, but all of them had a mean value of greater than 4 in a scale of 1 to 7, which concludes the tools to be more than "fairly" user-friendly. The only concerns were about two tools perceived to increase the workload due to increased level of alarms and concerns about information overload. These results indicating increased workload could be affected of the habit using the tools, which could be different if the participants were more experienced with the systems. The research found some tools decreased the workload as well and according to the VTSOs, overall STM will benefit their workload.

6.1 Future research

During the interviews the attendants came up with some suggestions to improve the tools of STM one is stated in the discussion section, about "Enhanced Monitoring" the ability to allow these alarms in certain sectors were one suggestion. A future research could be about how the tools can be improved to fit the VTSOs better, involving their opinions and their suggestions. Same goes with the personnel onboard, how would they like the tools to be for maximum usability? During the interviews the participants briefly explained how they used the tools; one interesting study would be to research how the VTSOs use the tools with observations as a method to see how much the STM implementation would change the work of the operators. Even though this study is small it points out the importance of evaluating the human centered design to make new technology beneficial for example the work load. The need of human factors involvement is necessary to the successful development of the e-Navigation.

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