Autonomous ships and the operator's role in a Shore Control Centre

A comparative analysis on projects in the Scandinavian region and the implementation of marine experience to a new field of shipping

Diploma thesis in the Master Mariner Programme

Peter Barthelsson
Jacob Sagefjord

Department of Shipping and marine technology
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2017

REPORT NO. SK-17/216

Autonomous ships and the operator's role in a Shore Control Centre

A comparative analysis on projects in the Scandinavian region and implementing the experience of Mariners to a new field of shipping

Peter Barthelsson
Jacob Sagefjord

Department of Shipping and Marine Technology
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2017

Autonomous ships and the operator's role in a Shore Control Centre

A comparative analysis on projects in the Scandinavian region and implementing the experience of Mariners to a new field of shipping

Peter Barthelsson
Jacob Sagefjord

Report no. SK-17/216
Department of Shipping and Marine Technology
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telefon + 46 (0)31-772 1000

Cover:
VTS Gothenburg operator station

Printed by Chalmers
Gothenburg, Sweden, 2017

Autonomous ships and the operator's role in a Shore Control Centre

A comparative analysis on projects in the Scandinavian region and implementing the experience of Mariners to a new field of shipping

Peter Barthelsson
Jacob Sagefjord
Department of Shipping and Marine Technology
Chalmers University of Technology

Abstract

Automation is a concept that is rapidly evolving in many fields. The development of autonomous cars and trucks are already being seen publicly. Autonomous ships is bound to follow but the complexity of ships creates a big challenge. The main reasons autonomous systems are under continuous development is to improve safety and reduce cost. There is a general demand that autonomous ships must be at least as safe as conventional ships. To make autonomous ships safe, human errors needs to be reduced as much as possible, while still having a human in the loop. This paper describes how to balance safety and costs when designing a shore control centre. A comparative analysis was conducted on three different projects to create a complete picture on the current concepts of autonomous ships. Especially on the ideas of the shore control centre and the operator's role in such domains. The conclusions were further discussed with actors in similar fields of work. This was done to establish how Bridge Resource Management can be adapted into the existing concepts for autonomous ships. The work routine of an operator could be similar to that of an officer and therefore, well established bridge routines should be looked at when designing a shore control centre.

Keywords: Shore Control Centre Remote Operator Autonomous Ships Bridge Resource Management

Acknowledgments

The authors would like to thank Yemao Man for the supervision, Robert Rylander from Viktoria Swedish ICT, Love Carlson for help in academic writing and everyone that took part in the interviews.

Table of contents

List of Pictures

Definitions and Abbreviations

AAWA - Advanced Autonomous Waterborne Applications
AI - Artifical Intelligence
AIS - Automatic Identification System
ARPA - Automatic Radar Plotting Aid
BRM - Bridge Resource Management
CET - Central European Time
Co-Nav - Co-Navigator (Controlling/Cooperative Navigator?)
CPA - Closest Point of Approach
DP - Dynamic Positioning
ECD - Electronic Chart Display
ECDIS - Electronic Chart Display and Information System
ETA - Estimated Time of Arrival
ETD - Estimated Time of Departure
GPS - Global Positioning System
IMO - International Maritime Organisation
IR - Infrared
MGN - Marine Guidance Note
MRM - Maritime Resource Management
MUNIN - Maritime Unmanned Navigation through Intelligence in Networks
Nav - Navigator
OOW - Officer Of the Watch
RADAR - Radio Detection and Ranging
SA - Situational Awareness
SCC - Shore Control Centre
SMCP - Standard Marine Communication Phrases
STM - Sea Traffic Management
UKC - Under Keel Clearance
VHF - Very High Frequency
VTS - Vessel Traffic Service

1 Introduction

From the general public's perspective, the shipping industry might not be perceived as massive as it is, since most larger ports has been moved to the outskirts of our cities. In 2015, 9.84 billion tonnes were freighted by the world fleet which is around 80% of the total world merchandise trade (UNCTAD, 2015). In 2014 the fleet grew by 3.5 percent, even though there has been a global recession in the industry since 2011 (UNCTAD, 2015). The industry has now stabilized, and there are no signs of the growth to slow down. It is now responsible for 3% of the total CO_2 emissions (Eide et. al, 2011), and as the industry grows, so will the environmental impact. With the current debate around global warming, solutions to the emissions from shipping has become an important topic.

Today’s world is dependant on shipping, with the world economy built on exports and imports. On a global market, rules and regulations is a complicated ordeal. No country can decide the rules for any ship that travels on the international waters. As it is now, ships follow the rules under the flag that they fly, which has lead to a concept called “flag of convenience”. It means that the shipping company has chosen the flag which has the most beneficial rules economically. Constant increase in competition within shipping has lead to a constant hunt for a flag that will benefit, to the cost of everything else. Especially the working conditions for sailors. Shipping today is in need of new innovative means of cost reduction.

There are around 89.400 vessels in the world today (UNCTAD, 2015), employing a lot of sailors worldwide. Between 2003 and 2012, According to Roberts S.E. et. al (2011) british sailors faced a 21x higher risk of fatal accidents than the general british workforce. There are also indications that personnel onboard ships can face a twofold or sometimes threefold increase in risk for some types of cancer, like kidney cancer, leukaemia, and possibly lymphoma (H Saarni, 2002). The study “The Mental Health of Seafarers” written by Robert T.B. Iversen (2012) have also shown that sailors face a higher risk of psychological illness, derived from multiple sources, such as loneliness, separation from family, stress, fatigue, lack of shore leave, short ship-turnaround times (short time in port), job security, cultural problems, abuse, criminalization and fear of piracy. In effect, these factors led to a 5.9% suicide rate on ships between 1960-2009 for all deaths. These numbers come with a large uncertainty because persons drowning after falling overboard can not always be determined as suicide, but most of them are suspected as such.

Autonomous ships could be the solution to all of the above stated issues in today's industry. It could solve the CO_2 emission, since slow steaming would be a more viable option. With less people working with each ship, the ratio between labour hours and bunker consumption would shift, allowing for longer journeys without labour costs getting too high. Having people working from shore would mean that they are less isolated from family and friends and that fatigue caused by external circumstances, such as storms, would no longer be a problem. Not being isolated would also mean that psychological health issues would be easier to spot and treat.

As the industry is expected to grow the demand for sailors will follow. It is expected that there will be a shortage of sailors once the economy recovers. The design of the shore control centre (SCC) could be one of the major challenges for a lot of stakeholders in the shipping industry, and the effect of this radical technological improvement and deployment upon the current ecosystem in shipping remains to be seen. Old navigational traditions as well as new technical solutions will have to be integrated into one system.

This study has researched ongoing projects within Scandinavia, with concepts and ideas that were developed separately; especially around the concepts concerning the shore side operators in charge of navigational tasks. The operators in today's shipping industry are the sailors and it is important to incorporate and take advantage of their skills and routines. Those skills were developed and built upon many years of experience and tradition. The projects researched have many similarities and differences, one similarity that is underlying for this study is that they are all talking about some kind of SCC. Some of the projects discussed is talking about employing operators. The vision of the operators vary between the projects, for example the level of remote control for the operator.

> Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) is a concept study, focusing on the feasibility of oceangoing autonomous ships (Rødseth, Ø. J., & Burmeister, H. C., 2012). As part of the study MUNIN developed an SSC concept with a lot of attention on interface design but very little on how this interface is used by the operator. A situation room was brought up for this reason, when a situation of a vessel is so complex that a single operator cannot handle it (Appendix 1 Interview Thomas Porathe). A bridge team in a conventional bridge environment takes over the con of the ship and works like a conventional bridge team.
>
> The ReVolt project is a concept study focusing on fully autonomous short-sea shipping in the Norwegian region (Appendix 2), with fully autonomous meaning that no operators are monitoring the progress of the ships. The vessels are traveling between different ports, charging the vessel automatically while it is loading/discharging. A remote control option will be needed as a backup system, but being a first step concept study, this area has not been discussed in this project (DNV GL).
>
> The Advanced Autonomous Waterborne Applications Initiative (AAWA-initiative) project is a concept study that has finished its first step (Jokioinen, E., 2016). The focus was autonomous vessels with a remote controlling option for monitoring by operators. Different concepts of operators handling the ships have been discussed in this study. A situation room like in MUNIN has been discussed but it is not a

priority. Details of the work of the operators has not been developed but like MUNIN, the operators will control a few ships each and will most likely have more responsibility of their vessels, since there is no situation room.

Autonomous shipping in Scandinavia is a new concept with a few projects, the projects researched in this paper has just finished their first phase. This paper was made to utilize existing experience from the maritime sector in the development of autonomous ships. The goal is to reduce the distance between the vision of the developers and the preferred work conditions of the mariner, this is made by gaining input from similar fields of work, such as VTS-operators and bridge simulator instructors.

1.1 Purpose

The purpose of this study is;

- To research where the leading projects in Scandinavia stand today and what concepts they have developed around the operators for autonomous ship operations.
- To compare how different developers concepts of human-machine interaction relates to the developed bridge routines of a deck officer.
- To use this information to identify which ideas and suggestions would be applicable for the design of future shore control centres, in regards to the perspective of human factors.

1.2 Questions

How can you reach the level of situational awareness required for the safe operation of an autonomous ship?

What is the most crucial information that should be available for operators to get an adequate understanding of the situation of multiple vessels.

How can you implement existing skills and experiences from a merchant mariner into the operator's role as the human part of the human-machine interaction?

1.3 Delimitations

This paper will be limited to the operation and human part of the shore control station. It will only include the technical, legal or business aspect if it is directly connected to the operators of autonomous ships. It will concern work that has been done, or is currently in progress, within or in connection to the Scandinavian region.

2 Background

This chapter consists of essential knowledge about shipping and ship handling to give insight into the maritime domain. Such as the design of different bridge systems today and how mariners are trained in the simulator. This chapter also gives insight into one of the most important concepts of navigational officers, Bridge Resource Management which is about bridge routines and how a bridge team cooperates efficiently.

This chapter also explains three different projects on autonomous ships in Scandinavia, their thoughts about the design of the SCC and the operators working in it. The projects have a few different concepts on the autonomous operation and ideas around the workstation for the operators.

2.1 Bridge System

When it comes to safety of navigation, the bridge system is a vital component. The bridge on a conventional ship can be thought of as the ship's brain. Here you control the ship's movements and communication. These actions are not automated, as it requires a bridge team to cooperate and discuss the best action for each situation. Some situations will be easy to handle and some complex situations will be difficult to grasp and requires a lot of attention.

2.1.1 Bridge Simulator

Picture 1: Chalmers Simulator Instructor System, with a screen with an overview of the area on the right and multiple screens on the left that shows the students instruments, possibility of switching screens between multiple simulator bridges.

A bridge simulator mimics a real bridge in a training facility. Digital projections of ships at sea are provided through screens and consoles (Hontvedt and Arnseth, 2013). In a separate room there is a setup for an instructor (pic.1) who supervises multiple bridge simulators.

Chalmers University of Technology has several bridge simulators with different design, where students and other actors in shipping can be trained to handle and control ships. The bridge simulators can be used in one of two different ways: on its own, running a simulation against vessels with predetermined routes; or with interconnected bridges where several controlled vessels can be simulated in the same situation.

The simulator instructors have their own station (pic.1) where they monitor the students vessels in an ECDIS-like screen. From here they can change the routes of vessels with predetermined routes, they also have full access to the student's instruments. The VHF communication is a connected radio between the instructor station and the bridge simulators, when students are communicating with other vessels, the instructors will take the role of the ships with predetermined course and use the relevant names.

The instructors are monitoring the students vessels at the same time as they are monitoring the computer controlled vessels, sometimes remote-controlling them. They are also handling VHF communication between the computer controlled vessels and the student controlled vessels.

2.1.2 Bridge Resource Management

Bridge Resource Management (BRM) or Maritime Resource Management (MRM) is a training programme that aims to give onboard crew and the shore organisation the ability to use and coordinate the knowledge, experience and the resources available to achieve and develop set goals for safety and efficiency. (chalmersprofessional.se, 2017)

There are many ideas and practices on how to manage a bridge in the most optimal and safe way. Since shipping is one of today's oldest industries the practices of bridge resource management stand on many years of tradition and knowledge. This chapter will introduce some of the concepts that mariners use almost every day.

2.1.2.1 Bridge Watchkeeping

"The AIM of bridge watchkeeping is to ensure the safe, timely departure, transit and arrival of ships. It is the underlying discipline of the nautical profession. Nobody else but ourselves has this responsibility and it is up to us to make sure that a ship is never put into a situation of uncontrollable risk." (Captain P. Boyle, 1993)

As long as there has been ships, there has been watchkeeping. Varying from the simplest form of the helmsman taking care of all navigational duties to a full bridge team. All of these setups are still in use today.

The master is responsible for ensuring that the watchkeeping arrangements are adequate for maintaining a safe navigational watch and the master can delegate authority to an officer of the watch to be responsible for the safe navigation of the vessel. (Captain P. Boyle, 1993)

2.1.2.2 Watch Arrangements

The Nautical Institute, Bridge Watchkeeping (Captain P. Boyle, 1993) (page 5) gives us the following guidelines to follow when composing a watch arrangement:

"(a) The composition of the watch shall at all times be adequate and appropriate to the prevailing circumstances and conditions and shall take into account the need for maintaining a proper lookout.

(b) When deciding the composition of the watch on the bridge which may include appropriate deck rating, the following factors, inter alia, shall be taken into account:

- At no time shall the bridge be left unattended;

- Weather conditions, visibility and whether there is daylight or darkness;

- Proximity of navigational hazards which may make it necessary for the officer in charge of the watch to carry out additional navigation duties;

- Use and operational condition of navigational aids such as radar or electronic position-indicating devices and any other equipment affecting the safe navigation of the ship;

- Whether the ship is fitted with automatic steering;

- Any unusual demands on the navigational watch that may arise as a result of special operational circumstances."

2.1.2.3 Fitness for Duty

The Merchant Shipping (Hours of Work) Regulations 2002 apply to all seafarers. A minimum of 10 hours rest in any 24 hour period and 77 hours in any seven day period is provided in the regulations. Hours of rest may be divided into no more than two periods, one of which should be at least six hours in length, and the intervals in between consecutive such periods should not exceed 14 hours.

The master has the overall responsibility that the officer of the watch is well rested, sober, healthy and fit for the watch. The owner or the operator has the responsibility that the vessel is manned enough to ensure that safe navigation can be kept at all times. (Maritime and Coastguard Agency, 2006)

2.1.2.4 Performing the Navigational Watch

From the point that the operator take over the navigational watch of the vessel and are responsible for the safe navigation of the ship, any errors the operator make can result in a catastrophic accident, putting the vessel, cargo, environment and human lives at risk.

It is essential that the operator is prepared and qualified for the duties of the officer of the watch. In order to keep a safe navigational watch, the officer of the watch is required to actively perform actions to best raise his situational awareness (SA) and reduce the risk of mistakes, so that at all times be prepared for any situation that may emerge and have an understanding of the vessel at that time, so that preventive measures is near at hand without long delay and the most appropriate action can be made.

The different actions can be to check the course, position and speed at frequent intervals, to ensure that the ship follows the planned route (Captain P. Boyle, 1993). The officer of the watch shall have full knowledge of the location and operation of all safety and navigational equipment on board the ship and the officer of the watch shall not be assigned or undertake any duties which would interfere with the safe navigation of the ship (Captain P. Boyle, 1993).

The officer of the watch should not leave the bridge until properly relieved (Maritime and Coastguard Agency, 2006). The master should be notified if any doubts arise that can compromise the safe navigation of the ship (Maritime and Coastguard Agency, 2006). The officer of the watch shall keep a record during the watch on the movement and activities related to the navigation of the vessel and take position fixes at frequent intervals by more than one method. (Maritime and Coastguard Agency, 2006)

2.1.2.5 Passage Planning

"Passage planning is a way of minimising the risk of navigational errors. With tighter schedules, reduced manning, faster turn-arounds and more intense operations, the requirement for pre-planning becomes even more necessary." (Captain L.Al Holder, 1994) (page 1)

Without planning, the time to process essential information may not be available at critical times in situations when the stress is high. The passage plan should include the whole voyage, berth to berth, with critical information of all events that will occur in the voyage. Specified and detailed so that they are easily recognised and executed without the need of looking it up at the spot.

According to Nautical Briefing, Passage Planning (Captain L.Al Holder, 1994) (page 3-4) when preparing the plan, the navigational officer needs to take several things into account, such as:

- UKC at all times, with regards to squat, pitch, roll, swell, predicted tidal height, heel and trim).
- Safe distances to dangers, with regards to weather, tidal streams, anticipated traffic, availability of safe water and navigational systems in use.
- Chart changes should be updated and all charts and publications should be up to date
- Traffic separation schemes
- Tidal information
- Visibility of lights
- Safe speed, with help from a ETA (Estimated Time of Arrival) plan
- Reporting points, VHF frequencies, VTS requirements, areas of special concern, pilot stations and tug points
- Contingency plans in case of emergency or bad visibility
- Equipment status
- Margins of allowable error like cross track distance
- Choice of ocean route (great circle, composite or rhumb line)

- Choice of ocean route taking considerations to weather and ice.

The master must check the route plan created by the navigation officer so that the plan meets all his requirements and then must brief the watchkeeping officers and make sure that the plan is kept amended and up to date for the intended passage (Captain L.Al Holder, 1994).

2.1.2.6 Cross-checking and Challenge & Response

Double checking your own work and actions minimise the risk that an error is made. This is something that should become normal practice of any officer (Captain L.Al Holder, 1994). Errors can still be made even if you double check your work, for instance, if the officer is wrong from the start. To reduce this risk, cross-checking can be introduced. Meaning that another officer double check the work from his perspective, if anything is wrong or unclear, they can work together to find a solution that fit both officers understanding of the situation. This in turn can, like checking your own work, minimise the risk that an error made by one person will have catastrophic consequences. (Captain P. Boyle, 1993)

When cross-checking, it is important to inform the officer if you find any errors. However, sometimes it is not clear that an action is an error, it may just be a sub-par action. In that case, when informing the officer you can use the concept of “Challenge and Response”. For example: “Are you sure that turning to port is the best decision?” or “Should we not turn to starboard here instead?”. This forces the officer to rethink his decision when an alternative solution has been presented. Ultimately, the decision may change or not, the point is to give insight to the officer so everyone has the same picture of the situation. For example the answer may be: “No, turning to port is better here because if we turn to starboard we head into another ship-to-ship situation that we want to avoid” or “Yes, you are right, turning to starboard is better here”. In both of these cases, the officers has the same picture of the situation and the risk of misunderstandings will be reduced during the action. (Johnston, N, 2003)

The aviation industry uses a “challenge and response checklist” (Johnston, N, 2003), which means that the co-pilot “challenges” the pilot before and after takeoff, making sure that every step of the checklist is cleared and that both pilots have the same view of the situation.

2.1.2.7 Standard Marine Communication Phrases and Closed Loop

Standard Marine Communication Phrases (SMCP) is a set of key phrases in the english language (IMO, 2000). As seafarers have unequal skill in the english language and the importance of effective communication is vital in shipping, using SMCP is a way to simplify ship-to-ship, ship-to-shore and onboard ship communication to avoid confusion and error (IMO, 2000).

According to “IMO Standard Marine Communication Phrases (SMCP)” (IMO, 2000) (page 10) the phrases has been compiled:

- To assist in the greater safety of navigation and of the conduct of the ship,
- To standardize the language used in communication for navigation at sea, in port-approaches, in waterways, harbours and on board vessels with multilingual crews, and
- To assist maritime training institutions in meeting the objectives mentioned above.

These phrases should be used as often as possible when communicating and these phrases are built around a concept called closed loop. Closed loop is a means of repeating the information back to the sender so he can be assured that the receiver got the right message and no misunderstands is present. A simple example of a pilot giving the helmsman a wheel order:
-“port twenty”
-”port twenty”
-”correct”.

2.1.2.8 Watch Handover

The watch hand over is one of the most crucial moments in watchkeeping (Macrae, C., 2009). Handing over the watch is usually done with a short briefing of the current situation and any relevant information on past events. It can be anything from malfunctioning equipment to navigational situations. However, there are a few things that shall be taken into account when handing over the watch. According to a Marine Guidance Note (MGN 315 (M)) (page 5) of the STCW a OOW shall:

- Ensure that the members of the relieving watch are fully capable of performing their duties
- Ensure that the vision of the relieving watch is fully adjusted to the light conditions
- Ensure that all standing orders and the Master’s night orders are fully understood

The OOW shall not hand over the watch:

- If there is reason to believe that the relieving officer is not capable of carrying out the watchkeeping duties effectively, in which case the Master should be notified

- When a manoeuvre is in progress until such action has been completed

The relieving officer shall:

- Prior to taking over the watch verify the vessel's estimated or true position

- Confirm the vessel's intended track, course and speed

- Note any dangers to navigation expected to be encountered during the watch

- Be aware of prevailing and predicted tides, currents, weather, visibility and the effect of these factors upon course and speed

- Note any errors in gyro and magnetic compasses

- Note the status of all bridge equipment

- Note the settings of bridge/engine controls and manning of engine room

- Be aware of the presence and movement of vessels in sight or known to be in the vicinity

- Give watchkeeping personnel all appropriate instructions and information which will ensure the keeping of a safe navigational watch, including maintenance of a proper look-out

2.1.3 Sea Traffic Management

The concept of Sea Traffic Management (STM) (stmvalidation.eu, 2017) is by using the technology that is available today to increase safety, reduce the negative effect on the environment and increase the efficiency at sea through information sharing and new smart services (sjofartsverket.se, 2017a).

According to sjofartsverket.se (2017a) some of the new services that have been developed in the STM are:

- Route Optimisation - every ship receives an optimised route to reduce bunker consumption, the route takes regard to weather, distance and water resistance.

- Route Validation - Ships can send their route to a shore based centre that double checks the route and makes sure that it is safe in regard to depth and zones that should be avoided.

- Monitoring - Ships that deviate from the route and are heading for danger, can be discovered early and corrected.

- Updated ice routes - The navigation equipment on board can directly receive and update new routes that are customised for the actual ice condition.

- Route exchange - Ships can choose to to share their route with other ships, the electronic charts will show the surrounding ships routes for easy understanding of the situation.

- Efficient harbour calls - Arriving and departing ships sharing plans and status information with the port, agents, pilots, boatmen, port control and other actors to increase efficiency in the port and to reduce the administrative workload.

2.1.3.1 MONALISA 2.0

Between the 2013-2015 the MONALISA 2.0 project assessed the strengths and weaknesses of ship- and transport systems, operations and interactions in the maritime sector. stmvalidation.eu (2017) writes the following about the conclusion of MONALISA 2.0: Defined a target concept and key performance indicators for four STM strategic enablers:

- “Voyage Management services will provide support to individual ships in both the planning process and during a voyage, including route planning, route exchange, and route optimisation services.

- Flow Management services will support both onshore organisations and ships in optimising overall traffic flow through areas of dense traffic and areas with particular navigational challenges.

- Port Collaborative Decision Making (Port CDM) services will increase the efficiency of port calls for all stakeholders through improved information sharing, situational awareness, optimised processes, and collaborative decision making during port calls.

- SeaSWIM (System Wide Information Management) will facilitate data sharing using a common information environment and structure (e.g. the Maritime Cloud). This ensures interoperability of STM and other services.”

2.2 Autonomous Ship Projects

There were three projects on autonomous ships researched for this study. The projects are similar in many ways, but some conclusions, around the autonomous concept, are slightly different. The different projects are in their infancy and have mostly consisted of feasibility studies.

2.2.1 MUNIN

MUNIN was a research study with eight partners led by Frauenhofer CML. The study focused on the feasibility of an ocean-going unmanned bulk vessel. Of the projects researched, MUNIN is the project that has the most publicly available articles published, and the study has also been finished and they reached somewhat of a conclusion.

“MUNIN stand for *Maritime Unmanned Navigation through Intelligence in Networks,* but it is also the name of one of Odins ravens in Norse mythology. The overall concept of the MUNIN project is likened to that of the raven, which is to gather information (cargo) around the world and bring it back to it’s master (destination).” (Rødseth, Ø. J., & Burmeister, H. C., 2012) (page 3)

MUNIN is limited to mid-sized dry-bulk merchant vessels on longer oceanic voyages and the whole study focuses mainly on the technical feasibility of autonomous ships, and less so on the regulations surrounding the subject. MUNIN envisions a ship that in the open seas will be able to, more or less, captain itself and only require human interventions in exceptional situations. When it approaches congested regions there will be a switch from an observational operation to a remote controlled operation, and maybe even on-scene personnel will take over the control, such as a pilot when approaching a harbour. The monitoring and remote control will be taken cared of in the shore control centre, where a few operators will monitor several vessels. (Rødseth, Ø. J., & Tjora, Å., 2014)

MUNIN envisions that a fleet of unmanned ships will be monitored from a shore control centre (SCC). These centres will have operators with training similar or equal to the STCW and master 5 licence and specific technical training adapted for the SCC . In the MUNIN project each of these operators would monitor 6 ships (appendix 1, interview T.Porathe) each the ships in turn will have predefined threshold limits, for instance, if the ship leaves its predetermined path and schedule, or if the onboard sensor system picks up an object that can not be identified, the operator will be notified. The article ”Situation awareness in remote control centres for unmanned ship” (Porathe, T., Prison, J., & Man, Y., 2014) (page 3) divides this into three different levels:

- “Indirect control. By updating the voyage plan during voyage, e.g. regular updates due to weather routing, or to avoid a declared NoGo zone, e.g. an oil spill operation. The autonomous system is still in control.

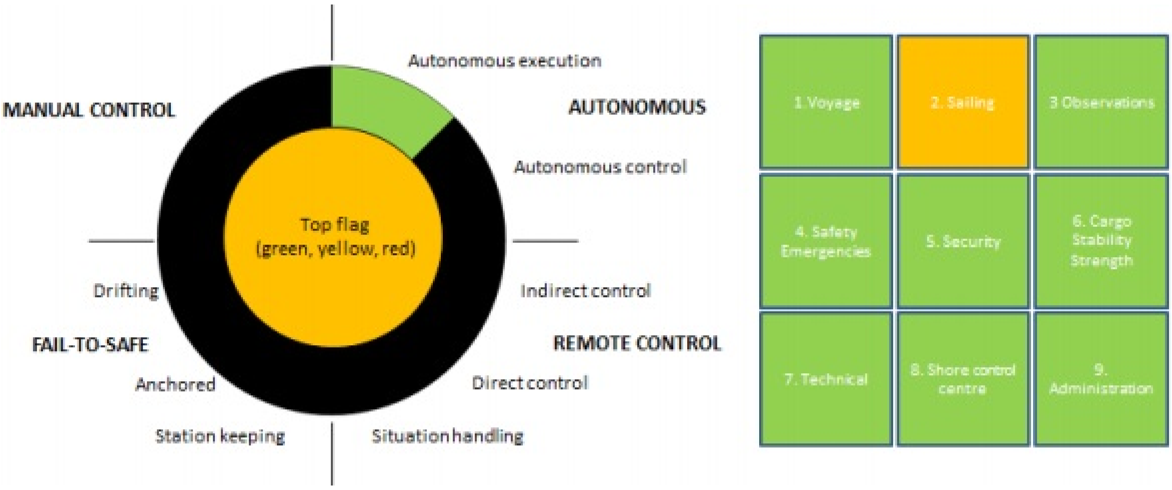
- Direct control. By ordering a specific manoeuvre to the vessel, e.g. heaving to give lee for a search and rescue operation. The autonomous system is still in control.

- Situation handling. In this case the autonomous system is bypassed. The shore based Officer Of the Watch (OOW) controls rudder and thrusters directly. This will be done from a “situation room” looking much like a present full mission bridge simulator on a maritime academy.”

2.2.1.1 Interface

The MUNIN interface is divided into several different views, each of which have a different level of detail for each ship. As Porathe, T. (2014) described in “Remote Monitoring and Control of Unmanned Vessels–The MUNIN Shore Control Centre”:

To avoid confusion while monitoring all six ships at once there will be a view with basic details for each ship. The primary interface in the MUNIN project is called “Top level indications”



Picture 2: Top level indications, showing what mode the specific vessel is operating in and the active alarm. picture: MUNIN

In the top level indications interface the operator will be observing a grid of 9 different squares numbered 1-9 (pic.2 right) Each square represents different categories of the autonomous ship control:

1. Voyage,
2. Sailing,
3. Observations
4. Safety and emergencies
5. Security
6. Cargo stability and strength

7. Technical
8. Shore control centre
9. Administration

The squares will show three different colors individually, green yellow and red. Green means that this specific category of the ship is working as intended, according to autonomous operation, without any immediate need of operator attention. Yellow indicates that autonomous operation is still active, but safe operation of this category is compromised and require attention from an operator. Red indicates that autonomous operation of this category is compromised and require the operator to take action.

Pic.2 left: The inner circle (in this example yellow) indicates the most critical alarm at that moment, while the outer circle indicates what mode this specific ship is operating in. The outer circle is divided into four equal sized areas, each representing four different modes. Autonomous, remote control, fail-to-safe and manual control. These four modes are also divided into different sub-modes. Which mode the specific ship is operating in will be indicated by the area representing that mode, showing up as green. In pic.2 left, the circle indicates that the ship is operating in Autonomous mode, in the sub-mode, autonomous execution.

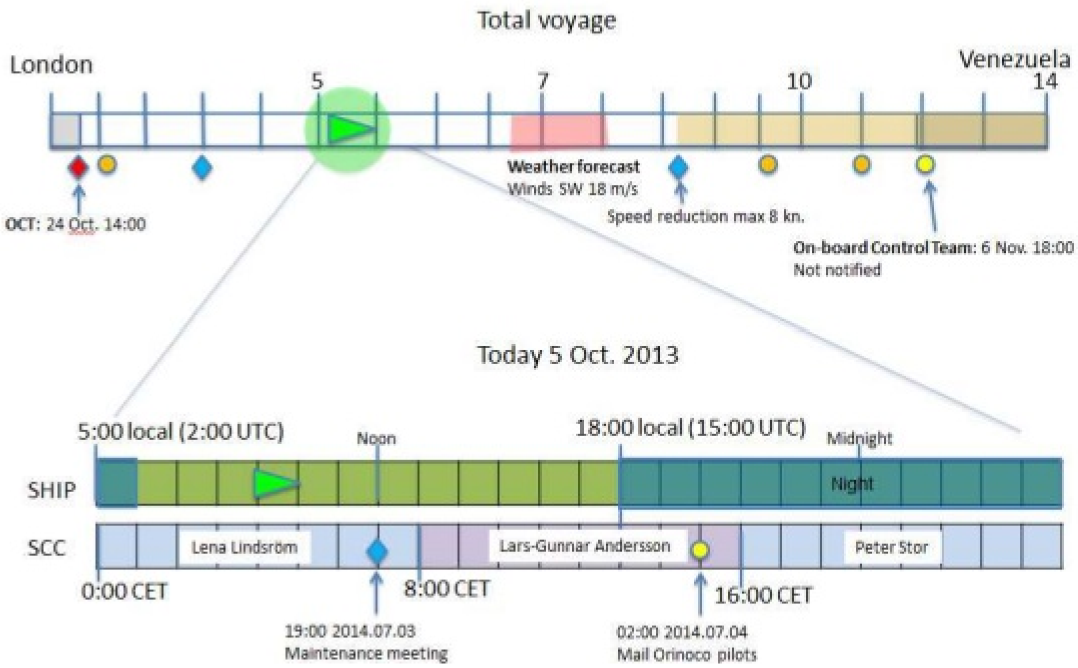
In addition the the top level indication, there will be a number of more detailed interfaces accessible, with specific information concerning categories such as route planning, operational status and the timeline of each vessel.
The interface concerning current position and route plan of the vessel is called “The spatial overview”

Picture 3: Spatial Overview, ECDIS screen providing information of the vessel and with AIS targets, the route plan is also shown. Picture: MUNIN

The spatial overview is an interface that is available to get a deeper understanding of the vessels situation. The Electronic Chart Display (ECD) or the Electronic Chart Display and Information System (ECDIS) integrated with Automatic Identification System (AIS) is a great tool for a quick assessment and understanding of what is going on around the vessel. Pic.3, left side shows a zoomed out overview of the voyage plan. Here the operator can change the intended route, for example if there is a storm, the operator can set a new track around it. Pic.3, right side shows a zoomed in picture of the vicinity of the vessel. The green box represents the planned position of the ship (Cross Track Distance).

All vessels in the water does not transmit AIS signals, so the operator can not rely on this screen alone. For situational awareness the operators might have to use the radar screen in conjunction with an ECDIS screen. Cameras could also be of use for this type of awareness and recognition, but is heavily limited to bandwidth (Rødseth, Ø. J. et al., 2013).

A more detailed view each vessels specific timeline will be accessible through a view called "Temporal view"

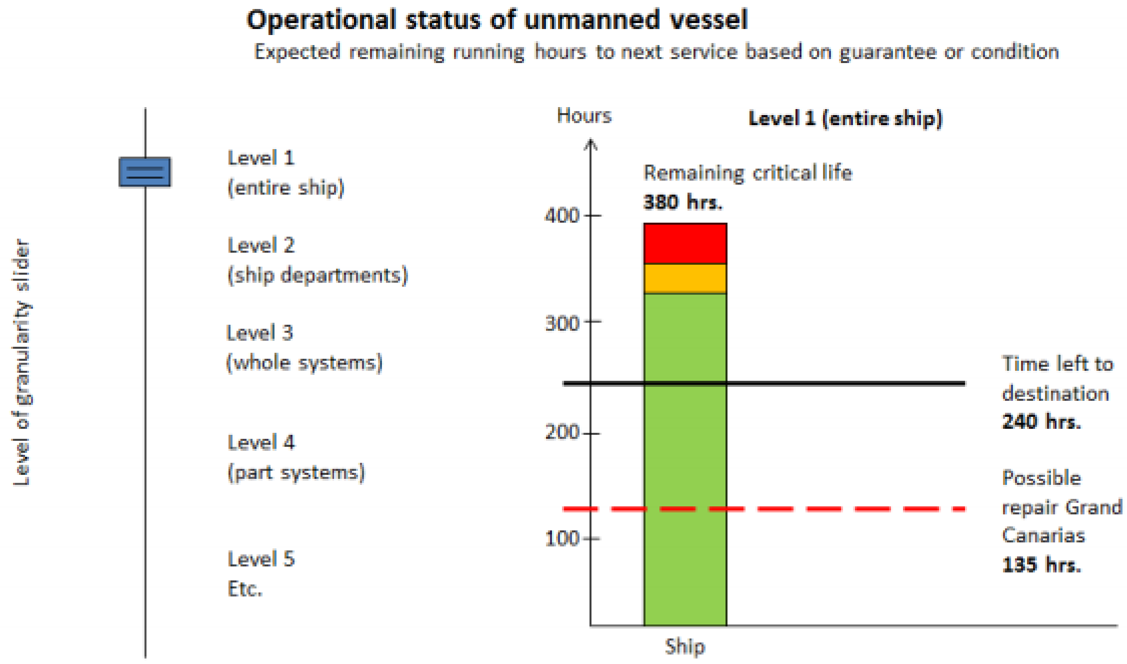


Picture 4: Temporal View, slot based diagram of events, history and predicted. Picture: MUNIN

Temporal View is a proposed design for keeping track of the schedule and specific events, it is based on a slot diagram. The top diagram (pic.4) consists of a timeline of the entire voyage and each slot represents one day. The operator can click on each slot to get a new detailed diagram of that specific day. The slots will now represent hours instead of days.

The different colored markers in the diagram signify events that are planned in the voyage. These events can be very different ranging from sending an e-mail or a maintenance meeting to speed reduction. With this system the computer can also notify in advance if two events are colliding. This view also shows who the operator for the specific ship is and who has the adjacent shifts.

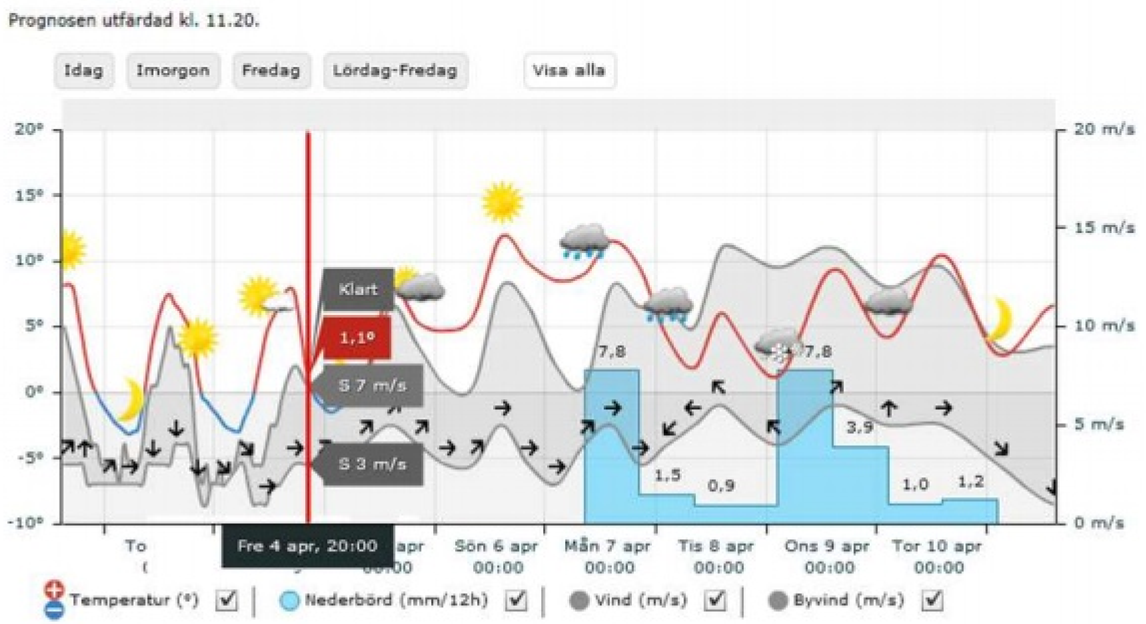
A more detailed technical overview of each system and the remaining redundancies can be accessible by a view called "Ship Status Indicator".



Picture 5: Ship Status Indicator, indication of the ship and sensor status, a column-diagram for easy understanding of redundancies. Picture: MUNIN

The Ship Status Indicator is a way to get a quick glance of how well the ship status is, how long time until maintenance is needed and how much redundancy is available. The operator can get indicators of the entire ship or can go deeper into every system down to individual parts or components. Green signifies that the ship is in a safe condition and redundancy is available. Yellow signifies that the ship is in a safe condition but with limited redundancy Red signifies that the ship may be in safe condition but with no redundancy. For every system the operator can check the redundancy by selecting the system and check the remaining expected life-time as well as seeing the time left to destination. There needs to be full expected redundancy for the full voyage and then some extra hours for safety. If the redundancy gets compromised and the vessel can not make it to the destination, there is also a line representing the closest port where emergency repair/maintenance is possible.

To get a better understanding of each of the technical systems one might use “Trend Lines”.



Picture 6: Trend Lines, line-diagram of specific information, history and predicted. Picture: MUNIN

Trend lines is a tool to check the history, the present and the prognosis of a parameter. The red line signifies the present and to the left of it is real measurements stored in the memory and to the right is the prognosis. This can be used for various systems within the ship, not only weather but also for technical installations and engine parameters.

2.2.1.2 Situation Room

Picture 7: Chalmers Simulator Bridge with RADAR, ECDIS and conning screens. This is how a Situation Room could look like, with camera-feeds from the ship or a 3D generated picture.

The MUNIN project briefly mentions a remote control option of the autonomous ship they refer to as a “situation room” (Burmeister, H. C. et al., 2014). This room is compared to that of a full mission bridge simulator. It has more or less the same setup as a normal ship bridge, with full access to all instruments and equipment that would normally be available in such an environment (Burmeister, H. C. et al., 2014). The idea is; as the ship encounters a situation that neither autonomous control or the monitoring operator can deal with, a team of trained nautical experts take full remote control of the ship and use their knowledge to solve the situation as a bridge team onboard a real ship would (Rødseth, Ø. J., & Tjora, Å., 2014).

2.2.2 DNV GL

ReVolt is a project by DNV GL (Det Norske Veritas), which aims to achieve a fully autonomous general cargo vessel for short-sea shipping by the Norwegian shore (DNV GL, 2015). The ReVolt project is finished and is moving on to the next phase, called the ReCharge project (Appendix 2). DNV GL is normally a classification and certification company, but is also a partner in the AAWA-initiative led by Rolls-Royce as well as having joint research projects with several other academia and industries.

In order to make a fully autonomous ship a reality, DNV GL believes that steps like sensor based monitoring, enhanced navigation assistance and remote operation has to be taken first (DNV GL, 2015). To create a situational awareness around the vessel, sensor fusion from sensors like ECDIS, GPS, RADAR, LIDAR and cameras will be used. These sensors will need to have more redundancies on a autonomous vessel than on a conventional ship, because there is no one onboard to repair them. Trusting a single sensor to navigate the ship safely is not reliable (Appendix 2).

The ReVolt's vision is a fully autonomous general cargo vessel for short-sea shipping by the Norwegian shore. The route that has been chosen for the ReVolt vessels is along the coast of Norway, from Oslo to Trondheim. This route is ice-free all year round and there are no locks (DNV GL, 2015). The longest leg of this journey is around 100 nautical miles.

With a minimum range requirement of 100 nautical miles, the ship will need to be able to handle itself for the duration of the voyage. The vessel is battery-driven and the recharge time is around 4 hours and will be recharged while in port (DNV GL, 2015). The vacuum based mooring system with inductive plates that is proposed in the project is a combined mooring and charging solution, this also removes the need of ropes and winches (Appendix 2). With expected port stays for over 4 hours, the ship will leave the port fully charged. The charging can be done with existing low voltage shore power, there is no need to change the infrastructure in the ports too much (Appendix 2).

The ReVolt ships is built to require as little maintenance as possible, rotary equipment is limited to only propulsion pods, two stern pods and one retractable bow thruster (1). Battery propulsion requires less maintenance than conventional propulsion. The battery room is split in two and when there is a need to replace the batteries, they can be lifted or dragged out of the side of the ship (Appendix 2). The ship has been designed to be ballast free, which further reduces the need for maintenance (DNV GL, 2015).

The cargo room has been designed to reduce the human involvement. Extending the hulls as high as the containers stack, there can be cell guides in the full height of the containers (DNV GL, 2015). This removes the need for lashing and stevedores. When the hulls are as high as the containers are stacked, there can be hatches on the cargo room. This is suitable to prevent water ingress in the cargo holds and to remove the need of bilge pumps that needs regular maintenance (DNV GL, 2015). These hatches are made of lightweight material and containers can not be loaded on them.

2.2.3 AAWA

The advanced autonomous waterborne applications, or AAWA-initiative (Jokioinen, E., 2016), is a project funded by the finnish funding agency for technology and innovation (TEKES). It includes research from Tampere University of technology, VTT technical research centre of finland, Åbo akademi university, Aalto University, and the university of Turku. It also includes research from members of the maritime industry, such as: DNV GL, Inmarsat, Deltamarin, NAPA, Brighthouse Intelligence, Finferries, ESL Shipping and Rolls-Royce which is one of the main stakeholders in the AAWA initiative.

The main objective of the AAWA initiative is to use already existing technologies and merge them into usable solutions for unmanned and remote controlled ships (Jokioinen, E., 2016).

2.2.3.1 Remote and Autonomous Operation

The vision is similar to MUNIN with an idea of a shore control centre, where operators will be monitoring and remote controlling several vessels at once. The operation will be initiated with Voyage planning, similar to today's planning in electronic charts such as ECDIS. With the difference that certain factors has to be taken into account regarding the autonomous and remote aspect. The operation will be heavily dependant on bandwidth and connectivity, and how much data transfer will be required for different legs of the journey (Jokioinen, E., 2016). There are also a limit in today’s maritime network infrastructure on bandwidth, especially in adverse weather conditions. This means that for example weather routing will be a more important part of the planning, especially for legs of the journey that are expected to require a heavier data stream.

There will also be an automatic system to verify the sea-readiness of the ship, it is imagined that most systems will be able to be checked remotely (Jokioinen, E., 2016). As for anything that can not be checked remotely, a shorebased crew is proposed to do the checks while the ship is moored in a harbour. When maneuvering out of the harbour area or other congested waters, there will ideally be a high bandwidth with low latency and the ship will be either directly remote controlled or supervisory control supported by onboard situational awareness systems (Jokioinen, E., 2016). The actual remote control operation is imagined to be like a dynamic positioning system, with a joystick-type operation, for example locking speed, heading or relative position to an object (Jokioinen, E., 2016). Another way described is by sending waypoints and the dynamic positioning computer takes over control of the propulsion.

When the ship operates in open sea, it will execute the planned mission, and it will autonomously follow the planned route (Jokioinen, E., 2016). During this stage of the journey the data transfer between the ship and shore is minimal, and limited to essential information such as: heading, speed, Estimated time of arrival (ETA) to next waypoint and key information from the situational awareness systems (Jokioinen, E., 2016). During this stage it will be possible for the operator to monitor several ships at once. The ship will constantly adjust the level of autonomy according to the current situation, if it starts deviating from the plan set by the operator this will automatically be forwarded to the operator (Jokioinen, E., 2016). How the operator is requested to interact will depend on the scenario. If for example the ship is deviating from the set path between two waypoints there will be a threshold limit on how much it can deviate without operator intervention (Jokioinen, E., 2016). If it is within these threshold limits, a notification is said to suffice, but if it is outside of these limits, the operator will be asked to intervene, either by remotely changing the course, or by choosing a suggested action by the computer (Jokioinen, E., 2016).

In “Remote and Autonomous Ships - The Next Steps” (Jokioinen, E., 2016) a specific design for the operator's control station is not described, but the vision for the operators role has been more thoroughly explored. The vision as described in the paper is that the operators will have a shifting role depending on the leg of the journey. From a heavily interactive direct remote control role over a few or a single vessel in digested and coastal waters to an observational role over several vessels in the open seas.

2.3 Related Stakeholders

Related stakeholders in this paper refers to parties which could have some kind of stakes in the future autonomous ships, such as insurance companies, vessel traffic services, coast guards, pilots or shipping companies.

There are several stakeholders that are interesting to look at when designing an autonomous ship. Input from each parts could bring good insight into how to design an SCC. As pilots that regularly are expected to safely manage a ship to berth, even if they have never been on that particular ship before. Vessel Traffic Service (VTS) operators that monitors traffic flows in congested waters, but also insurance companies that will have a lot to say when the autonomous ships are being built.

This paper primarily focused on the influence of VTS operators and their monitoring ability over the port of Gothenburg. As the office in Gothenburg is similar to the described concept of an SCC. Input was gathered from these operators because they have knowledge and experience of remote monitoring.

2.3.1 Vessel Traffic Service

Picture 8: Vessel Traffic Service with multiple screens providing AIS and RADAR information of the entire Port of Gothenburg

Vessel Traffic Service (VTS) is used as a term for sea traffic information and service for the sea traffic in congested waters or environmentally sensitive areas (sjofartsverket.se, 2017b), with the purpose to increase sea traffic safety and prevent pollution. VTS operators work with monitoring and communicating with vessels about traffic situations. (sjofartsverket.se, 2017b)

The communication with VTS is made over VHF-radio on specific channels. A VTS centre obtain positions from the vessels AIS (Automatic Identification Service) transponders and RADAR antennas stationed around the port, it can therefore present double checked positions and movements on electronic chart displays. (sjofartsverket.se, 2017b)

According to Thomas Johannesson (Appendix 5) there are three different service degrees of the VTS:

- Information service - The VTS is only assisting with information, and the vessels make their own decisions.

- Navigation assistance - The VTS is assisting with specific recommendations regarding the navigation in the port

- Traffic organization - The VTS decides how the vessels should navigate in the port.

The port of Gothenburg is an information service, which usually has one operator working at the time. The operator works in the building “Amerikaskjulet” and the operator control station is situated in the same room as Gothenburg pilot service and the Port Control.

3 Theoretical Construct

3.1 Human Factors

A big part of human factors consist of human errors, but human factors also refers to organizational factors (Macrae, C., 2009). There are many well thought out organizational human factors in shipping since accidents can, and has, led to disastrous events, such as loss of life, environmental damage and severe financial costs (Macrae, C., 2009). Human errors has been viewed as something caused by carelessness or ignorance, but in later years the influence of organizational factors has been proven as an element in shaping errors (Macrae, C., 2009).

Organizational factors can include; situational factors, referring to inappropriate equipment or clumsy procedures which lead to routine error traps that people can fall into or, production pressures and decisions making people under-resourced, leading to to poor performance (Macrae, C., 2009). Human errors can be described as a byproduct of poor organizational factors.

3.1.1 Human Error

75-96% of marine casualties are caused, at least in part, by some form of human error (Rothblum, A. M., 2000). Accidents are not often caused by a single mistake, but by multiple or a series of errors. In the dutch study by Wagenaar, W. A., & Groeneweg, J. (1987) "Accidents at sea: Multiple causes and impossible consequences", of 100 marine casualties, one or more human error was represented in 96 of those, it was determined that all of the human errors was necessary for the accident. Meaning that if just one of the human error had not been present, the accident would not have happened.

There are different types of Human Errors, sometimes being described as (Rothblum, A. M., 2000) (page 2):

- an incorrect decision
- an improperly performed action
- an improper lack of action (inaction)

An incorrect decision is a decision that when being given compromises the safe navigation of the ship, an improperly performed action is when the operator fail to follow the correct decision in a way that the safe navigation of the ship is compromised and an inaction is that the operator fail to act on the correct decision.

There are factors that can contribute to each of these errors, in the simplest cases only one factor need to be represented to make a human error, but in some casualties on ships there are more than one factor that is represented (Rothblum, A. M., 2000).

- Slips - Similar to absent-minded events like forgetting to turn the stove off or failure to recognize a small deviation on a system. Often, slips are quickly identified and corrected. (Blanding, H. C., 1900)

- Mistakes - Similar to slips but are separated by the intention, when carrying out an action and the intention is not appropriate, the resulting failure is a mistake, whereas in slips if the intention is appropriate, it would result in a slip if there is faulty execution. (Blanding, H. C., 1900)

- Skill based - Where the individual's skill is the dominant factor, it includes strength and physical stature required for a task and are often routine tasks. The importance of skill based performance on modern ships are greatly reduced. (Blanding, H. C., 1900)

- Rule based - Characterized by the application of rules and procedures for a task. As found in the operating manual, an instruction or checklists. (Blanding, H. C., 1900)

- knowledge based or cognitive - The ability to recognize and manage problems for which there are no definite instructions or solutions, by relying on experience or knowledge of the system. (Blanding, H. C., 1900)

- Automation Bias - Over-trust of an automatic system, if it is known that the automatic process identifies anomalies, the operator will not do so himself. (Porathe, T., 2014)

- Errors of omission - If the automatic system fails to identify system irregularities, the operator fails to acknowledge them at all. (Porathe, T., 2014)

- Errors of commission - Over-trust of an automatic system, where the operator receives poor advice or instructions from the system and fails to validate the data and ends up executing an action without the proper information for it. (Porathe, T., 2014)

- People - people come in all sizes and have limited strength, humans are great in pattern discrimination and recognition. A trained deck officer outperforms any machine in making sense of a radar screen. However, a machine beats us in precise and fast calculations and memory. Human performance is also determined by the training received and the skills and knowledge drawn from that. There is also other factors as fatigue and motivation. (Rothblum, A. M., 2000)

- Technology Factors - Technology design can have a large influence on the performance of an operator. For example, if a cutoff valve is ill placed and out of easy reach. The information that an operator needs to access is often neglected when designing an autonomous system. The most critical information is sometimes either not presented at all or presented in a way that is hard to understand. (Rothblum, A. M., 2000)

- Environment Factors - Environmental effects can include lighting, noise, temperature. The human body works best in a small temperature range, performance will be diminished outside that range. Bad weather and ship vibrations can cause stress and fatigue. (Rothblum, A. M., 2000)

- Organizational Factors - Human performance can be affected from by pressure from the company and crew organisation. Crew workload and their capability to perform safely and efficiently is directly affected by training decisions and crew size. Teamwork can be improved by free and interactive communication. Improper work schedules can contribute to fatigue. Pressure, company policies and tight economic conditions can increase risk-taking, for example, making schedule at all costs. (Rothblum, A. M., 2000)

3.1.2 Human-Automation Interaction

Quote from the article Human-Automation interaction (Sheridan T.B., & Parasuraman R., 2005) (page 89): “Automation does not mean humans are replaced; quite the opposite. Increasingly, humans are asked to interact with automation in complex and typically large-scale systems, including aircraft and air traffic control, nuclear power, manufacturing plants, military systems, homes, and hospitals” The future automated ships could be compared to that of the aircraft and air traffic control, having a shore control station that manages the traffic of several ships and decides their destinations and routes. The only difference being that the operations would be slower and stretch over a longer period of time. the task of designing such systems, and managing them by operators has not been, and will not be error-free (Sheridan T.B., & Parasuraman R., 2005).

Automation according to the Cambridge English Dictionary: “The use of machines that operate automatically”. Automation today has grown to include more than just machines that operate automatically and is happening in all aspects of human work, and has done so for some time. Not only in big machines such as ships or factories, but also in fully virtual computerized systems concerning for example economics. Work that was previously mental is being taken over by automated systems, and when using the word today it does not only refer to physical labour but also mental.

Humans can be passive benefactors of automation, for example, when we consume sources of energy, such as electrical power, fuels and water, that automation played key-role to provide. Human-automation interaction (Sheridan T.B., & Parasuraman R., 2005) (page 91) however refer to automation where humans either:

1. Specify to the automation a task with certain goals and constraints. For example an OOW of a ship using a computer on board to tell the ship to follow a track he sets on an electronic sea chart with a specific speed and limits to how much the ship can deviate from this track
2. Engineers programming a laser cutter to cut a specific part, in a series of parts to be cut
3. Computer engineers programming the movements of an autonomous car driving through a city.

3.1.2.1 Levels of Automation

Autonomy can be divided into different levels, or a scale of the degree of automation. Below you can see one of these scale of degree of automation made by Sheridan. It starts with level one which is no automation what so ever, and then in each step the degree of automation will increase. It is important to mention that for example an autonomous ship does not need to be one specific level, but each different part or application of the ship can have its own level, or even the same application can vary in its level in different times (in for example different sea legs of a journey or by operator input)

1. The computer offers no assistance; the human must do it all.
2. The computer suggests alternative ways to do the task.
3. The computer selects one way to do the task and
4. executes that suggestion if the human approves, or
5. allows the human a restricted time to veto before automatic execution, or
6. executes the suggestion automatically, then necessarily informs the human
7. executes the suggestion automatically, then informs the human only if asked.
8. The computer selects the method, executes the task, and ignores the human.

Picture 9: Sheridan Levels of Autonomy (Sheridan T.B., & Parasumaran R., 2005) (page 94)

3.1.2.2 Human-Centered Automation

Mistakes and inattention of the operator is often criticized as human errors, but is often a deeper and more complicated problem. When factors like technology, organisation and environment are incompatible with optimal human performance, human errors are often caused (Rothblum, A. M., 2000). Studies suggest that management often tries to pressure its personnel into not making mistakes, the human had to adapt to the system. As Rothblum, A.M. (2000) says "the human has been expected to adapt to the system. This does not work. Instead, what needs to be done is to adapt the system to the human."

The phrase Human-centered automation refers to the importance of taking the human into account when developing automated systems. That it has to be designed in such a way that it takes the human working with it into consideration. To not just engineer an autonomous system that "does what it should" and then expect the human to accommodate it. There are many different criteria on how human centered a system is, these are from the article "Human-automation interaction (Sheridan T.B., & Parasuraman R., 2005) (page 95):

- Allocate to the human the tasks best suited to the human, and allocate to the automation the tasks best suited to it. (Unfortunately, there is no consensus on how to do this; nor is the allocation policy necessarily fixed, but may depend on context.)

- Keep the human operator in the decision-and-control loop. (This is good only for intermediate-bandwidth tasks. The human is too slow for high bandwidth and may fall asleep if bandwidth is too low.)

- Maintain the human operator as the final authority over the automation. (Humans are poor monitors, and in some decisions it is better not to trust them; they are also poor decision makers when under time pressure and in complex situations.)

- Make the human operator's job easier, more enjoyable, or more satisfying through friendly automation. (Operator ease, enjoyment, and satisfaction may be less important than system performance.)

- Empower or enhance the human operator to the greatest extent possible through automation. (Power corrupts.)

- Support trust by the human operator. (The human may come to overtrust the system.)

- Give the operator computer-based advice about everything he or she should want to know. (The amount and complexity of information is likely to overwhelm the operator at exactly the worst time.)

- Engineer the automation to reduce human error and minimize response variability. (A built-in margin for human error and experimentation helps the human learn and not become a robot; see Rasmussen, Pedersen, & Goodstein, 1995.)

- Make the operator a supervisor of subordinate automatic control systems. (Sometimes straight manual control is better than supervisory control.)

- Achieve the best combination of human and automatic control, where best is defined by explicit system objectives. (Rarely does a mathematical objective function exist.)

To complement this, On Your Watch: Automation on the Bridge (Lützhöft and Dekker, 2002) (page 13) advises that automation will have to be:

- Event-based: Representations need to highlight changes and events in a way that the current generation of state-oriented displays do not;

- Future-oriented: in addition to historical, human operators in dynamic systems need support for anticipating changes and knowing what to expect and where to look next;

- Pattern-based: operators must be able to quickly scan displays and pick up possible abnormalities without having to engage in difficult cognitive work (calculations, integrations, extrapolations of disparate pieces of data). By relying on pattern-based or form-based representations, automation has an enormous potential to convert arduous mental tasks into straightforward perceptual ones.

3.1.2.3 Incidents and Accidents

When looking at incidents and accidents concerning the relationship between humans and automated systems the most common ones are around misunderstandings, over-reliance and feedback provided by system states. (Hancock, P. A. et. al., 2013)

In systems where there is a human in the loop, a higher degree of automation will not only benefit, but also cause new costs, different from those of fully automated, or non automated systems. Benefits from automation will be mainly in routine circumstances, while costs will occur when the automation fail and the human must intervene. For example, a factory cutting the length of steel rods. Instead of having a human paid hourly to do a monotonous task, there is a machine doing the task at a higher pase lowering the variable cost. However if the machine breaks the whole operation stops, and there will be costs in terms of loss of income and repairs. (Hancock, P. A. et. al., 2013)

4 Method

4.1 Step 1: Appraisal and Researching

Papers from the largest projects in the Scandinavian region were read to create an understanding on relevant parts of the autonomous ships. The three projects were: Munin, a project funded by Frauenhofer CL, with a lot of research connected to Chalmers, the AAWA-initiative, which is a project led by Rolls-royce and the ReVolt project, created by DNV-GL.

MUNIN was chosen partly because of the connection to chalmers, and the access to information was good, but also because of the projects focus on the human-machine interaction. Many of the articles in the study contains research around the operator, or closely related to the operator.

The AAWA project was chosen for its focus on remote control of ships, making the operator-role key element in their papers.

DNV-GL, and the project ReVolt was chosen partly because DNV-GL is a classification society, making them relevant when discussing legal feasibility of autonomous ships, but also because their study has a concept of a technically complete autonomous ship.

4.2 Step 2: Comparative Analysis

Once a good picture of the three different models were established, a comparative analysis of these projects was made. This was to establish;

Firstly, in what areas are the conclusion similar or the same, so that the feasibility of these conclusions can be strengthened.

Secondly, in what areas do the conclusions differ, and why. This will help to get an understanding of areas where the different projects could benefit of each other, but also to identify these areas so they can be brought to external stakeholders for examination.

Thirdly, compare what areas has not been researched by all three projects, so that ideas that could work across the projects can be transferred between them to make them more complete.

How did they think differently and what was the most fundamental ideas. To do this, interviews were conducted with researchers involved in the different projects to fill in eventual gaps, and to get a more updated view of where they stand now, and also get more specific answers to the different questions that were chosen.

4.3 Step 3: Identifying Gaps

With the three different concepts well documented, the ideas were taken and presented to stakeholders with relevant positions in the industry today. The stakeholders chosen was VTS Gothenburg and Chalmers simulator professors.

The VTS was chosen because the descriptions of the work of operators of autonomous ships was in some ways similar to the work description of VTS-operators; VTS operators sometimes also manages and makes decisions on the movement of several ships at once.

The Chalmers simulator was chosen for very much the same reason, but also because tests around autonomous ships has been made for the MUNIN project in these simulators. Another reason was because of the experience the instructors has around monitoring students, and their role to identify mistakes made when operating ships and advanced autonomous machinery.

There were two different interviews, with a number of general questions that was asked to both of them, and also specific questions that were asked depending on the role of the person interviewed. In these interviews we focused on adapting existing bridge routines in a shore control centre environment. Challenges and eventual gaps and preferable ideas was identified from both actors. Half a day was also spent observing the work at the VTS, to get a more clear view of exactly what was meant by the answers in the interview.

4.4 Step 4: Integrating Bridge Resource Management

With the comparative analysis and the information from actors in similar fields of work, the thoughts of these actors complemented the concepts of the projects. Followed with a discussion on how these bridge routines can be adapted to a shore control centre environment and a fundamental concept around the ideas were built and presented in this paper.

4.5 Interviews and Ethics

In the interviews with scandinavian developers, and in the interviews with the stakeholders they received mostly the same questions, with some variations depending on their field of work.

The participants have been given the opportunity to answer freely and to discuss around the questions. The interviews were built in a way that all participants have been asked roughly the same general questions. Furthermore there have been specific questions depending on the participant’s project, field of work and knowledge/experience.

The importance of these interviews is to get an understanding of the different project’s vision of the future SCC. How the operators will remote monitor and remote control their autonomous vessels and what actors from similar fields think about them. The different views that are important are the ideas and solutions on situational awareness, humans as part of the chain of automation, different sensor information and how to present it to the operators on different legs of the journey and how to adapt Bridge Resource Management to safely incorporate those routines into an SCC.

Full interviews will be available in the appendixes and the participants that have been interviewed are:

- Thomas Porathe, NTNU, former Chalmers, part of MUNIN
- Hans Anton Tvete, DNV GL, part of ReVolt and AAWA
- Eetu Heikkilä, VTT, part of AAWA
- Christopher Anderberg, Chalmers, DP course instructor and simulator teacher in the master mariner programme
- Anders Johannesson, VTS Gothenburg, VTS operator and VTS Training Instructor

This paper will refer to the persons with their first names, Thomas, Hans, Eetu, Christopher and Anders or will be referred to the company they are representing.

5 Results

During the development process of autonomous and unmanned ships, all developers agreed that a human in the chain of automation is important. They believe that the human will play a smaller role as the automation increases. When the projects finally reach their desired form of automation, human intervention will be minimal, whether it is fully autonomous or remote monitored. The developers vision as of now is that in either case of desired mode of operation, a remote controlling system should be available. This system can be designed in a number of different ways, but will focus on the same things, reducing the human errors and making the system more efficient.

In this paper the results are described in a way that explains the different projects (MUNIN, ReVolt, AAWA) views on the different challenges and topics. It also describes the different stakeholder views on these, or similar challenges and topics

5.1 General pros and cons of Autonomous vessels

5.1.1 Cost

There are a few things all developers agree with, such as the benefit of slow-steaming, and the cost reduction in a ship built without facilities for humans. In the interview with Thomas, the possibilities of having ships circulate the high seas at very slow speeds, or even just drifting in currents was discussed. What makes this possible is the reduction of variable costs, such as labour hours. The removal or reduction of on board personnel will open up the ability to keep the ships out at sea for longer periods. However, there will still be the need of regular maintenance. When discussing this with Wallenius they said that their conventional ships could go maintenance free for a period of 35 days, but that is assuming that nothing out of the ordinary happens.

Other over-time costs related to having humans onboard would also be reduced, such as fresh water, heating, provisions and also indirect human related costs such as travel expenses. The ship construction could also cost less, when considering all the spaces onboard meant for humans. However, when building a ship that has all the structural redundancies required for unmanned operations, the cost reduction can be debated.

The topic of redundancy is mentioned in all interviews, and not having humans onboard means that everything that previously demanded the attention of humans, such as cargo handling and navigation, will have to be redundant. In the interview with Thomas, one of the things he mentions regarding this, is that 2 radar systems might not be enough, and that 4 independant radar systems could be more suitable.

AAWA, MUNIN and DNV GL all mention the need of additional sensors, such as CCTV cameras, infrared cameras, lidars and other high tech appliances. The technology integrated in these ships will cost more than the technology in most ships today.

5.1.2 Safety

One thing all the developers have in common is the importance of safety. It has to be at least as safe as modern ships today but preferably even safer. They all argue that human error is a big part of accidents in the maritime industry today. As Hans Anton Tvete from DNV GL put it:
"Working as a mariner is a dangerous occupation. Marine accident statistics indicate that up to 80% of accidents are caused by human errors, these errors could be reduced with autonomy. Removing people from the ship will also reduce the risk of human injuries. Factors like fatigue, stress or homesickness can also be taken out of the equation with a computer or a machine."

Another safety issue that the developers argue could be eliminated, is the accidents caused by fatigue onboard traditionally manned ships. Thomas from NTNU talks briefly on the topic of situational awareness while being on shore during a storm compared to being on board. Feeling the storm and having the SA from being present compared to experiencing fatigue from lack of sleep because of the storm. He also raises a question about Estonia, why did they keep speeding through the storm, in spite of feeling the stomping of the ship? Another thing he mentions that there are sensors to measure the stress and force that the ship is put through, but that the problem is how to forward this to the operator so that he gets as high a level of SA as possible.

When discussing this topic with Dynamic Positioning (DP) instructor Christopher, he believes that, it will be tiring and inconvenient to go through a storm, but not to a degree where focus on the task at hand will be compromised. As long as routines are followed and the job is done as intended. He continues to mention, that a storm is bound to cause unpredicted issues that require the presence of onboard personnel.

Anders Johannesson mentions, that from his perspective as VTS-operator, if he was to decide on how the ships should navigate, he would require more time, and bigger marginals for every decision. He also mentions that in the bigger ports, the operators are responsible for the movement of the ships, and that it seems to work just fine, and also that as an operator his bird's-eye view of things seems to be a lot better than that of the ships. He continued to say that if the VTS operator could alter the routes of the ships entering the area, they would be able to manage the ships and their safe navigation.

5.1.3 Environment

How autonomous ships will affect the environment is something that is not thoroughly explored in the interviews but there are a few things discussed and it is mentioned in the different projects papers.

Something discussed with the developers is slow-steaming. It is not only a good thing from a cost perspective, but also from an environmental point of view. They have the view that, lower bunker consumption per ship will lead to less burnt fuel which in turn will lead to less pollution. Efficiency will be increased with a thorough and consistent autonomous system for maneuvering and route planning, with the implementation of the STM system Thomas mentions that for example collision avoidance can be implemented ahead of time.

5.2 Situational Awareness

Situational Awareness is a key point when safely working as an SCC operator. The answers on how to reach a high level as possible of SA as possible varies, depending on who is asked. Eetu from VTT believes it is more of a question of redundancies, because the sensors are capable of producing the needed situational picture. Looking how reliable the sensors are and how they work in different environments, is the first step to understanding what level of SA can be achieved on an unmanned vessel. Thomas says that the operator should at least have the same information available, that is available on board conventional ships. Because mistakes, can lead to serious damage. While operating multiple ships, new possible mistakes emerge, for example if the operator change course on a ship that he think is another ship, that the operator are not aware of the weather-situation, if it is dark or bright outside, if he is heading for a fishing vessel or a buoy. Any of these new factors could help create an accident.

When discussing the technical aspect with Christopher he says that when it works, it works really well. He mentions that there is a general belief that the development has to take a few steps back. The more automation of the operators work routines, the more they are losing their Situational Awareness.

If the operator are put directly into in a situation where he have to understand a complete traffic situation, it will take time. From Christopher's experience as a simulator teacher he says that to only realise that there is a close danger and to understand the basic status of a ship can take 30 to 60 seconds. If there is a more complex traffic situation, it will take longer time to develop an understanding of the situation. Christopher continues to say that the operators should monitor ships in one area, so that the operator do not control a fixed amount of ships. Instead he is responsible for all ships in an area, that way the operator builds a Situational Awareness in that area. Even if the operator will need a watch handover, he still has the basic understanding for predicted traffic movements in the area.

When discussing the topic of SA with Anders, he says that the more a system can handle itself, the better. He talks about how humans easily miss things, for example getting a cup of coffee can take a minute and somethings can be missed. The VTS operators are building SA by looking at the screens and listening on the radio-traffic. The VTS system is designed to help the VTS operator to get a greater understanding over the traffic situation in the harbour as a whole, so that he can effectively inform and assist ships in the area. He continues to talk about the alarm system and that he finds it insufficient. For example, the system can not warn for a ship that is slowing down, this is an action that could be very hard to notice. Any alarm that warns for situations out of the ordinary would be convenient.

There can be a risk when the ship is occupied with an action in addition to navigating safely in the harbour. For example when taking a pilot from a pilot boat. Sometimes the ship needs to make a course change so that the pilot boat can approach on the leeward side. The ship and the pilot boat will be occupied with the operation of safely embarking the pilot and they lose their Situational Awareness. Sometimes when they make the course change, they do not notice that they are turning into a collision course with another vessel in the vicinity. The VTS operators are monitoring closer in these kinds of situations when they occur, because Anders believes that the they have a better overview than the officers on the vessels as they have a helicopter perspective.

There are also scenarios where ships have better SA than the VTS. An example Anders mentions is when two vessels head towards each other, while there is a third vessel overtaking one of the vessels. Then the vessels involved usually have a better sense of the situation than the VTS. There needs to be an assessment made if there is enough time and distance to overtake .This assessment is usually easier for the vessels to make themselves.. In these cases it is only the VTS operators job to inform the vessel that is overtaking that there is another vessel further ahead. Anders feel that in any ship-to-ship situation where a more accurate assessment of time is necessary, the deck officers on the ship bridges will have a better SA than the VTS operators.

5.3 System that Challenges the Operator

In MUNIN there was a proposition on how to keep a basic understanding of the positions and situations of the operators 6 ships. It was proposed that the operator looks deeper into each ship once an hour. Taking 5-10 minutes for each ship, checking the surroundings, sensors and redundancies. This will help to keep the operator in the loop, because he/she will be occupied with looking at ship statuses. This leads to the operator having a schedule or checklist about what to look at. If he/she does not look at a ship for over an hour, there will be an alarm.

Another way of keeping the operator in the loop that was discussed with Thomas is having a system that asks the operator to perform a task. For example it could ask the operator to take a bearing to a lighthouse and then comparing it to the GPS or the RADAR. This would help the operator build an understanding of the accuracy of the sensors. At other times the system will ask the operator to compare the depth curve and the echo sounder. This could subconsciously teach the operator to use depth curves for positioning.

When discussing this topic with Eetu, he also believes that a system will need to make itself engaging to the operator, Eetu thinks that one way of doing this is by using cameras, he thinks that one of the biggest problems for operators in autonomous systems is boredom and cameras could prevent this by making the task more interesting. However there is still technological improvements that needs to be made to make video streams possible. Eetu also talks about situations where an operator manages several vessels that are geographically disconnected from each other. He says that it in these situations it is even more important to keep the operators engaged, especially since there will be a need of keeping a high degree of SA in many different areas. Since there in an ideal operation will not be much input from an operator necessary, his proposition on how to engage the operator is routine tasks that upholds the SA, for example checklists.

Christopher says that “You are in the loop when you give yourself the conditions to setup the operation. However, when you are in the loop, you slowly take yourself out of the loop over time, the less you interact with the systems.”. He continues to say “To work with keeping humans in the loop, you can have drills about how the systems are built and how they work. You can test out different scenarios to understand together what you can do and not do. In a DP operation, for example a diving class 3 operation, pushing buttons to keep yourself in the loop is not the right way to go, if you push the wrong button, then you can put the divers at risk.”

When running a simulation and taking control of the ships that are not student-controlled, Christopher mentions that he and the other teachers can feel that they are not in the loop. It takes time to quickly build SA on multiple vessels. Christopher says that two vessels can be maneuvered fairly well, more than that and you have to split the vessels on several teachers. However, he emphasizes that these simulations are very fast scenarios with tight traffic situations.

When observing the work in the VTS, it became clear that the system challenges the operator by itself because of the reporting points. When a ship crosses a reporting point, it has to contact the VTS with information of where they are headed and they receive information back from the VTS operator about the traffic situation ahead of them and other relevant information. This way the VTS operators have to be in the loop at all times, because the ships are expecting to receive information from them. There is also a factor of repetition, because there is multiple vessels and multiple reporting points. The system will also alarm for different things, when a ship is heading out of the fairway or if a ship is dragging anchor. This is to ensure that the operator makes as few mistakes as possible.

5.4 Information that needs to be Available to the Operators

In MUNIN, a focus group consisting of deck officers brought forward 145 data-points that should be available for the operator, like air pressure, wave height, wind direction etc. When the operator is monitoring vessels, he will most of the time be monitoring in the Top level indication screen. If there are no alarms present, this screen will show green lights and the ship’s operating mode status (described in chapter 2.2.1.1). If there is an alarm one of the green lights will turn yellow or red, and this indicates lack of redundancy of a system or errors such as connectivity issues. The light that turns to yellow or red will represent a category, and by clicking it he can access more information on that category and the specific alarm. He will also be able to request a relevant camera feed in this category.

The interface and the information for the operators in the AAWA-Initiative has not been described extensively. When asking Eetu about the information that should be available for the operators, he says that the most important thing is to know that the ship is doing what it is supposed to be doing. Basic status information and an indication that everything is working fine. The engines are running as they are supposed to, the automation and other ship systems are working.

Christopher explains that, from the perspective of a deck officer, a bridge environment is mostly about anti-collision and navigation. To prevent the ship from running aground, with instruments like an electronic chart connected with a anti-collision system to prevent the ship from colliding with other vessels. He says that in a remote controlled setting a camera-feed would be desired, but pictures could work if the bandwidth is too low.

He continues to say that In anti-collision situations the distance and time are the most important factors, your ships movements in relation to the other ships movements. In anti-grounding situations the important factors are to see around the ship, through a picture, but it can be defined in multiple ways. One way could be depth curves connected to safety depth, that will automatically highlight the areas that are navigable for the ship, so that the operator can easily spot what water is available.

The more complex a situation is, the more information would be required for it. Christopher says that a common mistake students do in the simulator is that the information is present on the screens, but they fail to recognise it. They are occupied with other things and not on the available information.

The VTS service provides ECDIS-screens with AIS- and RADAR information. Which provides vessels with vectors on the ECDIS-screens, similar to a ARPA system. What should come soon is STM and Mona Lisa, which would enable the operator to see all the vessels routes on the ECDIS-screens. Anders says that he doesn't feel that he needs to see the ships RADAR as they have their own shore-side RADAR. However, to receive a camera-feed from the ships would be more beneficial, so that the operator can see what the ship sees. However, he also says that there could be a risk with that, if the officers on the ship do not see what the VTS operator see in their camera. The operator believes the ship have the same picture of the situation but he cannot tell if they are busy with something else and missed what the VTS operator saw in the camera-feed.

He continues to mention that In anti-collision situations, closest point of approach (CPA) is important, but also the time and place. In anti-grounding situations, something that would be helpful would be if the VTS system could use the individual vessel's drafts that is provided from the AIS and integrate them into a dynamic alarm system. This would mean that the system could then set separate depth curves for each vessel based on their draft. For example if a ship's draft is 8,5m, this information could be provided to the system and if it headed for 8.0m depth, the system would alert for that specific ship. As it is today, the VTS system is alarming for the same set areas for all ships.

5.5 Pro's and con's of being on shore versus being on a ship

The goal for many developers is to achieve unmanned ships, this means that the mariners that work as operators on these ships will work from shore. Working from shore creates new possibilities, but also adds some restrictions. When discussing this with Thomas, he says that "If you work at sea and after some years wants to start a family and get a job onshore, you can still operate ships from a shore control centre. There will be new jobs. More desired jobs. Of course the romantic part of the job, like seeing the world, would go missing. But you can see that the average age for seamen that starts looking for shore-based jobs is decreasing". There was also a discussion with Thomas about the factor of being in a storm, it is good to be on the ship when there is a storm, to get a feel for it. However, it can be very hard to get a night's sleep and the officer might get severely fatigued.

When asked the same question, Eetu says one advantage would be that ocean crossings could be unmanned and the operator would not be isolated for extended periods at sea. There is no need to work in storms or harsh environments. There is also a safety factor, Eetu believes that ships are still not as safe as they should be. In regards to occupational safety, it would be safer to work in a shore control centre. However, the disadvantage would be that the operator lose the sense of the ship. When you are working on the same ship for years, you will learn how it behaves and what problems it has. Something Eetu states is that the developers don't know how the mariners will feel about it yet, will they be content with operating their ships from shore or will they feel that they cannot do their work there.

As someone who has worked at sea for several years, Christopher says that if something happens on the boat, the remote operator would not be there to observe what happens. If a fire starts somewhere, perhaps the fire detector would detect it too late, but if there was a human present he might notice it earlier by walking past, seeing smoke or by smell. Also, complications easier emerge for simpler things, such as an oil leak in the hydraulic oil system, a simple task for a crewmember on board, but it could be very advanced to fix remotely. However, Christopher also mentions that in reality, an ocean crossing is pretty meaningless from a navigational point of view. The interactivity from a nautical perspective is very low.

5.6 Human as part of the chain of Automation

In time there could be fully automated systems, but for a long time the development will be depending on real sea-experience. Thomas says that the automated systems are not wiser than they are programmed them to be. It’s a development that has to happen, the systems needs to be made smarter and it is possible to use machine learning or deep learning for this. He continues to say that in the beginning it is very important for officers to be there, to watch and interpret the systems of an autonomous ship. It is officers with sea-experience that knows how weather affects the ship's hull and also knows how other types of vessels react in the maritime environment. A major challenge may be how regular vessels will interact with autonomous vessels and adapt the systems to this.

ReVolt are focusing on full autonomy but also states that it will still be important to have a human in the chain of automation, as Hans puts it: “It is important to have humans as part of the chain of automation, whether it is shipping, land based industry or general society. Increasing automation is about making life more comfortable for the people, so people has to be part of the chain. A ship is not built because of technological improvements, it is built to satisfy a transportation demand.”

Eetu says that it is a continuous development, in the first 10 to 20 years it will be absolutely crucial to have a human in the loop. The technology is very new and has some uncertainties. However, After 20 years, it might be completely unnecessary.

Christopher says that as long as ships are like they are now, there will be a need of a human intervention because ships are very complex and unexpected things tend to happen. Sometimes the situation will require a pinpointed action, which the automation can not handle.

5.7 User-Centered System

As of today the IMO User-centered Guidelines is not a requirement for the developers, they decide themselves how the interfaces are designed as long as the sensors are working according to the requirements. Thomas thinks that the users should be involved in the design from the start. He hopes that it would mean that a system is built around user-studies, that its tested iteratively during development, and tested on users in the end. This should be the basis for a user-friendly system. Every manufacturer can say that their system is user-friendly, but it doesn’t have to mean that it is. It’s a matter of standardising, the industry wants to develop freely and find new innovations to make money on a new gadget. Thomas continues to say that he hear that users only use a small part of the system and don’t bother with many of the finesses in the RADAR and ECDIS, because the users never have time or are bothered to learn.

When asking Christopher about user-centered systems, he says that in theory, they seem good but they rarely work as good as expected in practical circumstances. User-centered systems has been a discussion for a long time, but as long as the rules and classifications look like they do right now, it is very complex to integrate the user's perspectives into the systems. He continues to mention that it happens several times that systems have been installed on board and the operator receives a one hour crash course before the technician has to fly home. The installed system ends up inactive because the information required to use the system was not thoroughly thought. The relation between mariners and developers is a loop often does not work. Sometimes the developers change a system that has worked satisfactory in the past, just because they develop a new aspect. Christopher continues to say that the bridge simulator instructors see that the students only use 20% of the ECDIS when it is in monitoring mode and the students still navigate the ship properly.

5.8 Existing bridge routines

MUNIN circumvented the question of bridge routines by introducing the Situation Room. In this room all existing bridge routines would still be used, with officers working in a team in the same way as on a conventional bridge. Thomas adds to this that the operator is only an operator that monitors that everything works. When necessary, the ship will transfer into the Situation Room with a bridge team. The line between operator control and Situation Room is hard to define, because the operator will be able to take direct and indirect control from his work area in situations that are not too complicated.

In the AAWA-Initiative where remote controlling is a large factor, Eetu says that there have not been as much talk about existing bridge routines as it should have been, but there have been discussions with officers of some small ships and small ferries.

Anders says that the routines of a VTS operator does not have very much in common with conventional bridge routines, there is a difference between maneuvering one ship and taking consideration of several ships in an entire port. The VTS is not meant to be a co-pilot to the ships in the area, the VTS is meant to mediate information and help build a domain and situational awareness for the ships. The VTS is sitting alone and can therefore not work in bridge teams. In harbours where VTS have multiple areas and operators, there is still only one operator responsible for his area and no formal cooperation between the operators.

5.9 Situation Room

The MUNIN situation room is designed to handle complex ship-to-ship situations that the autonomous system alarms for. When the operator believes that the situation is too complex a bridge team will be used for the safe operation of the ship. when The bridge team enters the Situation Room information from the vessel's sensors will be loaded on the screens. The idea is that the situation room will be similar to a bridge simulator. . They proceed to work like a conventional bridge team, solving the complex situations that emerge. The problem is that the team don’t have any situational awareness at all when they receive a ship. It requires time, which in complex situations, is difficult to get.

Picture 10: Chalmers Simulator Bridge

In the AAWA project there has been talks about a Situation Room or a remote bridge. But Eetu believes it is not pursued that much, what AAWA is developing is a more virtual command centre where they don’t even try to mimic a ship bridge. They instead provide the information that the operator needs and try to optimise it as much as possible, in ways that improve SA and keeps the human in the loop.

Christopher agrees that a separate system that can add more people, like a bridge team, must exist in some way. A Situation Room would be one solution.

5.10 Competency and Training

In MUNIN the operators are only monitoring the ships and making sure that everything is working as intended, Thomas say that the operators can take direct and indirect control. In the early stages, they will have to be trained deck officers. Then it is a question of how robust the autonomous systems can be made, how much collision avoidance can be put on a STM-system. Perhaps the operators don’t have to think about anti-collision anymore because the STM has already solved the situation. When there is an alarm and a ship transfers to the situation room, the bridge team will consist of trained deck officers.

It is generally accepted that the operators still need to have real experience at sea before being able to be a remote operator. However, Eetu says that the operation on shore would be so different, that it would require a completely different education, possibly adding operator courses to the already experienced deck officers. The goal is to make a system that is so easy that experience at sea would be enough, but the operators will also need to understand how the ships operate autonomously. He continues that it is especially important in the period of time where we have autonomous ships and conventional ships at the same time. If all vessels on the sea were autonomous it would be very easy to develop a anti-collision system, because the computer would not have to adapt to human behavior.

The operators that works in VTS Gothenburg have a deck officer background, usually with sea experience of a few years.

5.11 Fewer Manning onboard instead of Unmanned Autonomy

Most projects look at the complete picture, but Thomas personally thinks that the road there is the most interesting aspect. There can be a possibility of sending the sensor information ashore and receiving input from a person remotely. In this case Thomas says that there could even be a possibility of the officer of the watch taking a quick nap in the middle of the ocean when the person ashore is monitoring his vessel. This idea can be developed into unmanned bridges during night watches in open sea.

He continues to say that for example, in the English Channel, there can be a bridge team that is partly remotely connected. There can be one or two officers on the ship and one or two persons ashore that is connected through sensors and cameras, working together like a bridge team. Thomas mentions that there is a possibility that off-shore vessels could be autonomous when going to harbour, but the complex DP-operations would be operated by officers on the vessel. There is also a little talk about alternative solutions, like fleets and platooning.

When discussing the topic of fewer manning with Eetu, he says that the first thing that comes to mind is the regulation. How much crew there has to be on a ship, these regulations might not change very quickly. He continues to say that fewer manning on board may not be a good solution. No one would want to build an autonomous ship and also have to construct systems designed for humans. There is a large potential saving in the construction of a ship, when not having to think about accommodation, freshwater systems etc. That is a reason most shipbuilders would want to build a unmanned ship right away. Eetu says that this would not be applicable when testing an autonomous ship. There needs to be people on board when testing it and then you would have to build a conventional bridge and some other systems that could otherwise be disregarded.

5.12 Organisation and Design of a Shore Control Centre

Thomas says that in the MUNIN project the shore control centre should control around 100 ships to be profitable. Especially when considering the maintenance and the navigational planning. The navigation department plans routes and connects to the STM. The engine department plans maintenance and the logistics around spare parts. The operation department controls 3 stations with 30 ships each. A Situation Room per each station should be available, Thomas also adds that, preferably, these will stand unused most of the time. He says that they are counting on the vessels being autonomous 99% of the time and use track follow mode or artificial intelligence (AI). It is only 1% of the time that the operator has to go in and take over the control and only a fraction of this will be situation room operations.

5.13 Redundancy

Redundancy is something that will be demanded by insurance companies, they will require that the ship is fully redundant at all levels for a set number of hours. However, redundancies are not only in place to satisfy the insurance companies. Thomas makes a point by giving an example from a bridge on a ferry that had all screens black out. Apparently a video splitter, that relayed the radar picture to several screens, lost its power. The splitter had not been fed from the backup power. The point was that extensive research needs to be carried out to figure out exactly what needs to be redundant, slips like these can not be tolerated when there are nobody onboard to handle the situation. If something breaks, what does that mean for the entire ship. Does it result into only one system faulting or does it affect the whole ship.

The MUNIN system is a system that warns when the redundancy jumps down one level, for instance green level to yellow level. It is possible that two RADAR-screens will not be enough, there might need to be four screens that are independent of each other. In that case, if one RADAR breaks, there will still be three systems left and a green level. If one more breaks there will only be two left and the system goes down to yellow level. When there is only one left, then there is no redundancy left and the system goes to down to red level. The ship might still run satisfactory but there is no backup system for the RADAR anymore. Thomas says that the question is what to do when the redundancy go down to red level, perhaps stopping the ship and sending out a tug boat. These are considerations that must be dealt with.

The ReVolt project is heavily invested in redundant systems, since the vision is full automation. The battery rooms are split in two and there is a very low maintenance for battery propulsion. All the sensors will be needed to have built in redundancies, Hans Anton said that the operator can’t rely on a single sensor to navigate the ship safely. He continued to say: “On autonomous vessels there is a need for redundancies, because there is no human presence. A naval officer on board a conventional ship is a form of redundancy. The same for engineers, if something breaks down there is an engineer present that can repair it.”

Eetu says that the sensors are capable of producing the needed situational picture but it is unknown how reliable they are and how they work in the environment. It is an issue of optimisation to improve and adapt already existing systems to the maritime world. That is why redundancy is very important, we cannot fully trust a single sensor.

5.14 Dulled by Alarms

Thomas said that in the MUNIN project they talked a lot about alarms that warn too often and the risk of the operator ceasing to trust the alarms. If the GPS signal is lost on a conventional bridge, then multiple instruments will sound an alarm. It would be better with only one alarm. Thomas says: “The developers have to design their instruments this way, there are specific requirements when designing a system for that. How many false or irrelevant alarms can there be before the operator risk to miss a real alarm. Volvo has a system that shuts down some alarms when driving faster than 100 kph and that is something the maritime sector could think about.”

The VTS system alarms every time a vessel with AIS is leaving the fairway. Anders says that more and more leisure crafts have AIS today, so that particular alarm goes off every time one of those vessels exit the fairway. There can be so many alarms, that there is a risk that the operator stops reacting to it.

5.15 VHF and Communication Delay

Thomas says that in worst cases, there can be a 8 second delay with VHF-radio. If there is VHF communication between an unmanned and a manned vessel, the system has to send the signal through satellite to the SCC and back. That would take 16 seconds just between when the operator hear the end of the ship's message to when the ship on the other end start hearing the operator's message. Considering the operator don’t need time to think about what to say.

In archipelago navigation there is a need to complete the communication quite fast. VTS operators use the VHF-radio extensively and Anders says that a delay of 10-20 seconds would be absolute maximum in their case. If the operator don’t need to communicate but just give information, 20 seconds delay would be acceptable. If the operator beforehand knows that there is a delay, in that case there would be enough time to say everything that the operator wanted to say.

6 Discussion

An effective design and organisation of a shore control centre is a vital part in the safe navigation of all remote- monitored and controlled ships, in the same way that an effective bridge team increases safety. There are many aspects of design and organisation around the shore control centre and in the results chapter we heard many different takes and ideas. In this chapter we take the core ideas and concepts and add Bridge Resource Management elements, to better understand how we can effectively set up a shore control centre.

6.1 Human Redundancy

The crew on conventional ships are a form of redundancy, when things break, there is an engine department to solve the problem. On the bridge when safe navigation is compromised, redundancy could be to add more people, such as a lookout or a co-navigator. On unmanned ships, it is necessary to substitute this with more technical redundancies on the ship and human redundancies in the shore control centre. By human redundancies we mean that the humans work as a team and backup to each other and the system itself, very much like two computer systems would backup each other.

One of the most critical issues onboard a ship which have been connected to many accidents in the maritime industry is the change of shifts or watch handover. Thomas emphasizes the importance of a good routine regarding this. Especially when moving the operators to shore, since each operator will be responsible for more than just one ship. When looking at BRM there are many guidelines and work-routines to make the handover as safe as possible. In most cases where accidents happen, these routines were not followed.

We would like to see developers take these routines in regard when designing future systems since they should still be applicable, even if the operational task itself has changed. There are also many things that can be improved when moving the operators ashore. Many of the limiting factors in work routines exist because there are people on board the ships. They are isolated from the world and there are limited resources. A very beneficial aspect of being ashore is that the operator does not need to be isolated and alone on a bridge, there can be two or more persons working in vicinity of each other. There is also the possibility of having assisting personnel, such as technical or navigational advisors and team leaders working in the same building, or even the same room.

6.1.1 Operator Pairs

One example of using the advantage of being on shore and the advantage of the well developed bridge routines would be for two operators to work next to each other. Each of whom is still responsible for 6 ships as in the MUNIN project, but each ship has a defined primary operator and secondary operator. Meaning that the operator-pair will operate 12 ships, each operator will be a primary operator for 6 ships and secondary operator for the other operators 6 ships. This operator-pair would be able to use the concept of cross-checking, much like a navigator and a co-navigator on a conventional ship. If one of the primary operator's attention is compromised there will always be a second pair of eyes to double-check and to notice if something is out of the ordinary with the ships. Of course you are not limited to 6 ships each like this example, there is a possibility of 4 ships each and each operator-pair monitoring 8 ships.

In MUNIN, they had a vision that the ships will be autonomous 99% of the time, when an alarm do occur, the primary operator will have to handle that alarm. Which means that the operator's attention to his other 5 ships is compromised for the duration of the alarm. During that time, the secondary operator can take a more active role for his 5 ships to help him out and if he feels overwhelmed he can always request the team leader to help him out.

6.1.2 Situation Room

In MUNIN there is the concept of the situational room, with an independent bridge team ready to take over full remote control over any of the ships from the control station, similar to that of a bridge simulator. Since the team would only be required in critical situations, they would be expected to take over any ship anywhere in the world, situational knowledge of the ship would have to be acquired very quickly.

Discussing this with both Thomas and Christopher, and from our own experience of being put in various situations in a bridge simulator, we concluded that this is a very hard thing to do. In the simulator we usually have a period of at least 20 minutes to prepare and plot our position. Even then, the situation can be confusing when the simulation starts. When navigating a conventional ship, the OOW will have a very clear picture of where he is and what is happening, often he will have taken part of the passage plan days or even weeks in beforehand, and most of the times he will be familiar with the area he is sailing in.

If one of the operators in the shore control centre, receives an alarm and need to transfer one of his ships into the Situation Room, he could easily hand over the monitoring of the other 5 ships to the person sitting next to him. He could then focus on briefing the team on the situation of the alarming ship through either a video link, or he could join the team in the situation room to lead the operation. This would mean that, a person that has knowledge of that particular ship, and the geographical area would be involved in solving the critical situation.

6.1.3 Watch Handover and Overlapping Shifts

Another benefit of having operators working together in pairs would be the possibility of them having overlapping shifts. For example, if each operator works an 8 hour shift, with each shift overlapping the other with 4 hours. This would mean that when Lars-Gunnar starts his shift at 8:00 CET and takes over after Lena, Frans Backe has already been working for 4 hours (See picture below).

Picture 11: Example from MUNIN. Adding a diagram for the Secondary Operator when viewing a specific ship's Temporal View. Here is also an indication of shift overlaps.

This would mean that, there is always someone present with knowledge of past events. On a conventional ship on a normal watch, there will usually be one navigator responsible for his watch, and when there will be a watch hand over, where a new navigator take over the watch. They will have a short briefing where crucial events and standard information is mentioned and then the new navigator will be left to his duty. If something is forgotten in the briefing or any other past settings or events that needs to be understood, he will have to call the first navigator on his free watch. If there was always someone there with past knowledge sitting next to the operator, that person could easily be asked directly. The threshold of acquiring information around any unclarities would be significantly lower.

Another benefit of this could be that the handover itself could be made safer. While the two operators that are changing shifts are doing their handover, the other operator, who still got another 4 hours left on his shift, can keep an eye on all ships.

6.2 Keeping the Human in the Loop

Keeping the operator in the loop is a difficult challenge when designing the shore control centre. MUNIN had the idea that the operator would take 5-10 minutes to check the status on his ship every hour, for all 6 ships. Not only checking that there is no alarms but the operator could also monitor their position and traffic situation, a potential dangerous situation might be discovered and there is a possibility to avoid it before it happens. In any case, when an operator needs to take action, he/she will have a prebuilt situational awareness because he have looked at that particular ship within an hour.

6.2.1 Understanding the Systems

To be kept in the loop, the operator first have to understand how the systems work. How does the autonomy in the ship behave. If the operator see a potential dangerous situation before the system alarms for it, is taking over the controls immediately necessary or can the autonomy take care of it. If the operator is trained to know how the autonomous vessels react, there will be a better understanding about what the vessel is capable of doing and what situations it can handle itself. As Eetu said "The goal when designing the system is to make it so easy that experience at sea would be enough, but the operators will need to understand how the ships operate autonomously."

Taking the crew ashore will eliminate the need of conventional drills, but new drills will have to be implemented. Just like VTS operators go back to the simulator every once in awhile, an operator needs drills to understand the autonomy. Not just how they are built and how they work but also to test out different scenarios together. This is not only to understand the systems but also to train the operators to safely manage their ships and in what context the operators will be required. Just like a regular simulator session with briefing, execution and debriefing. The goal is to learn something and take new experiences back to work.

6.2.2 Operator plans the Passage

An important factor is to understand how the operator gives himself the conditions to be in the loop, setting up the operation and planning a passage requires the operator to think ahead. When planning a route the operator has to go through the route beforehand in his head, thinking about various situations that might emerge. When operating the vessel the operator have the preparation to fall back on. One example could be, knowledge of the location ferry crossings. The operator have it in the back of his head that there might be ferries crossing ahead of the course.

If the operator have planned a route, he don't have to take as much time into thinking about where the ship is headed and where the turn commences. If the ship is, because of a previous situation, devoid of the route and a new situation arises, the operator will understand the area better if he planned it. This enables the operator to build his situational awareness and put more time into thinking how to solve the situation, instead of looking ahead and seeing where the route ends up and where the ship is headed.

6.2.3 System that Challenges the Operator

Eetu Heikkilä said that the system will need to make itself engaging to the operator, because at times there might not be a lot to do. Then there needs to be a routine for the operator to check some things, because boredom is a big factor. There is of course a variety of ways to stimulate and occupy an operator's work time. But the understanding of how to do it effectively is a difficult task.

Thomas says that one idea would be to make the system challenge the operator. The system will ask the operator to perform a task. For example, take a bearing to this lighthouse and compare it to the GPS sensor, not only is it an automatic double-check with the sensors, the operator also builds a situational awareness which helps with keeping the operator in the loop.

When observing the VTS, we noticed that the VTS operator was well in the loop at all times, when asking VTS operator Anders Johannesson how they kept the operator in the loop and how they build situational awareness, he answered: “by looking at the screens and listening to radio traffic”. But it became clear to us that the largest factor that the operators was so well immersed in their loop was because the system challenges the operator indirectly. There was only a few times that the VTS system alarmed, when a ship is heading out of the fairway or when a ship is dragging anchor, the last alarm would also occur when a ship is leaving the anchorage, which worked as a way of telling the operator exactly when the ship started moving.

However, the way the system indirectly challenged the operator was very interesting. Every time a ship passed a reporting point, they had to contact the VTS and tell them what point they were passing and where they are going. Every ship did this for a number of carefully placed reporting points in the fairway. This way, the operator will build a situational awareness, because they know exactly where each ship is and where they are headed at all times in the VTS area. Not only this, but the VTS operator also gives back information to the ship at each reporting point. The information is mostly about the traffic situation ahead of them. This induces a concept of repetition, that is important for keeping the human in the loop, as Christopher Anderberg put it “When you are in the loop, you are slowly taking yourself out of it”. This means that repetition is an important factor to keep the operator in the loop. Another advantage of this in the VTS system is that every ship in the VTS area is required to listen to the radio traffic, so in turn they also build a great situational awareness and are regularly kept in the loop.

6.2.4 Checklists and Alarms

Checklists are used extensively in the maritime industry and will have to be transferred and adapted to a shore control centre environment. When sending an unmanned vessel from shore, there will be very little control of what happens on board. If anything is forgotten, then it might be very hard to do something about it. Checklists can be used in various situations including but not limited to:

- Arriving/departing berth
- Arriving/departing VTS area
- Arriving/departing other areas
- Taking/handing over a ship (not to be mixed up with watch handover)
- Taking over a ship in the Situation Room
- Entering congested waters
- Entering narrow passages
- When expecting bad weather.

Checklists will not only be used so that the operator does not forget anything, but will be important for the operator himself, as a tool to build situational awareness and to keep the operator in the loop. Checklist for handovers would also be beneficial for bringing the operator into the loop. Presenting checklists in an autonomous ship setting can vary, because there are new conditions. There is a possibility of several checklists in conventional paper-form and there can be digital checklists that talks the operator through every point on the list. Like a co-navigator would do. This could work in conjunction with the system that challenged the operator and asked him to perform certain actions.

In a way every alarm could work like this. Instead of having only a red flashing light, there can be a voice telling the operator that he should look into the redundancies of a vessel or that there is a situation that the autonomy cannot handle. Every alarm becomes a task. In a shore control centre where there is sensor fusion, there should be a fused alarm system, similar to what they did in the MUNIN interface, Top Level Indications. This is important to not get too many alarms. If one of the systems lose the GPS positions, there should only be one alarm.

6.3 Types of Operators

There is a lot of talk about each operator being locked to his own specific ships. When looking at how the shipping industry operates today, this would likely result in the ships being spread across different oceans. Since every ship has its own unique situation that needs to be understood, this could lead to a problem of keeping high enough level of SA on every ship. For example, routine checks, like the checks proposed in MUNIN, could take longer for an operator with his ships spread out, than an operator who is monitoring all his ships in the same area.

In the interview with Christopher Anderberg, he said that building situational awareness around an area is important. So instead of having limited situational awareness of the spread out ships, there is a possibility of having an area-operator. This operator would have situational awareness of his own area, and only control ships within it. In this area he would only be in charge of ships in similar situations.

The area-operator, learns the behavior and traffic patterns in the area he is working in, as a VTS operator that have SA in his VTS-area. This kind of area-operators could take over ships from the regular operator in some congested or coastal waters, for example the narrow parts of the English Channel and in most harbours. One idea would be to have regular operators and area-operators working together. When the ships leave an area that an operator is controlling, they hand over the ship to the operator that controls the adjacent area or a regular operator that does not control an area. Controlling ships in open sea will not require as high situational awareness like controlling an area because there is almost only an anti-collision factor. There is a possibility of only having area-operators, then you need a team of area-operators monitoring a large area of an ocean. The further you get out on the open seas, the larger areas an operator can monitor because there is less traffic and deeper waters. However, the larger areas that is monitored, the larger the advantages of having area-operators is diminished because it would be harder to gain SA and your vessels would be in multiple weather systems.

The VTS in Gothenburg harbour only needed one operator for the entire area, unless there was an unusual event. Which means that it is possible to have large areas for every operator. In very large areas were several operators needs to have adjacent areas, there needs to be some sort of watch handover between the operator. There is also a possibility of putting a reporting point between the areas, so that when the ship enters a new area they report to the operator in that area. From that point, the operator takes over that ship and relieves the former operator. In this case, there needs to be an overlap in the areas.

The area-operators work will be very similar to what VTS is doing today and have a similar setup as the VTS system, except that the operators would be able to control the ships that enter the area as well. We discussed this with Anders Johannesson (VTS Gothenburg) and he mentions that if they could alter the routes of the ships entering the area, they would be able to manage the ships and their safe navigation. The ship is autonomous and would most likely never need help for anti-collision. However, managing the traffic flow in an area from a VTS perspective, would be really useful. Since they have a good overview and can look ahead more effectively. They also have knowledge about the ferries in that harbour, where they are headed and what times they arrive and depart. An area-operator could direct the traffic flows, deciding if the second channel is more suitable for this ship or to slow down a ship because a ferry is about to depart ahead of it.

Having area operators and regular operators working in the same SCC would be advantageous from a human factors perspective. It would open up many possibilities to make the work more stimulating and dynamic. For example the operators could switch places occasionally and learn to operate different stations and take different roles more often. Of course this would not only be limited to operators switching places, there is also the possibility of operators switching with team leaders or support staff. This would also mean that people working in the SCC would get a greater understanding of the operations as a whole. The whole centre becomes more redundant when staff are sick or otherwise absent, if there is more than one person that can run each specific station. However, it is important to manage how often, people should be moved around, and how many areas one person should be allowed to manage, since situational awareness could suffer.

A disadvantage of having area operators would be the logistical feasibility, at least when looking at how the shipping industry looks today. Having operators assigned to specific areas would compromise the flexibility of ship movements. Since shipping companies do not control where and when cargoes will be transported, and often does not have a specific schedule with exact estimated time of arrival (ETA) and estimated time of departure (ETD), knowledge of how many ships will be in certain areas will be difficult. This would mean that either; the SCC will have to be very redundant in terms of personnel with situational knowledge of each operating area, or that each operator should be able to control a larger number of ships. New problems in terms of efficiency in such a centre would present themselves. For example, one area could have 70 ships at the same time as another has 3. The operator's workload would be hard to manage. One solution could be that a prognosis is made each day, and operators are assigned to specific areas on a daily basis, and builds a situational knowledge of the area assigned a few hours before taking over the control station.

6.4 Fully Autonomous or Remote Controlled

All developers we spoke to seems to agree that, in the long term they want to minimize human involvement in the automation as much as possible. They see a gradual reduction of human-machine interaction as the technology advances. However, when looking at current studies of human machine interaction there are many that claim that the systems with a human in the loop needs to be adapted more to how the human functions. This means, that the systems we will develop in the near future might be adapted more in regard to the human than before.

There is a risk that, when the human is removed from the loop altogether the gap between the fully automated system, and the human-automation system will be quite big. Since most systems move toward more autonomy and less human intervention, at the same time as there is more and more development towards a system that is better adapted to the human. This could be an argument that systems should continue to be developed like before, with more regard to making each task more autonomous, and try to educate operators to adapt to the system, instead of adapting the system to the operator.

Recent statistics seem to point toward the fact that, in this century the accidents has gone from being caused by machine malfunction to human error. This is mainly the argument for making systems more human centered. It is important to point out however, that overall, the accidents has decreased. From this point of view the question is if the human error accidents really has increased or if they only represent a bigger part in comparison. How important is human-centered design of autonomous systems, if the longterm goal of automation is to exclude the human altogether.

6.5 Gradual Development of Autonomous Ships

A point that Eetu Hekkilä makes concerning the manning of autonomous vessels, is that no one would build an autonomous vessel and also want to take into consideration the accommodation and environmental systems. Especially since they are already expensive ships that needs extra sets of sensors and extensive redundancy

However, when testing an autonomous vessel, there needs to be crew on board, to learn and monitor the systems. They also need to know what degree of trust that can be put into them. This could for example be an old ship that is set up with sensors. Testing could also be done with a system that works as a watch assistant, setting up the sensors and systems on ships that are already in regular traffic. The system can propose actions that the deck officer can choose to execute, if they deem it appropriate. This information could then also be used as data when further developing the autonomous control.

When developing and testing the concept of the shore control centre, developers could take information from the sensors that are already on the ships and then load it to screens on shore. This would give them a sense on how high situational awareness can be achieved, even if they can not control the ships. Such a system would not only be useful for the development of the SCC but could also be used as a system that work as an assistant for existing ships. If an operator get tired for example, and the ship is in the middle of the atlantic, he could take a nap, and someone monitors the ship from shore.

When discussing the beginning of autonomous vessels, there might not have to be a question on whether each ship needs to be partly manned, or unmanned. Inspiration could be had from the autonomous vehicle industry where there is examples of platooning trucks. This means that there is one truck in the front that is manned, and that other unmanned trucks will follow autonomously in a line. Something similar could be made with ships, you could have one ship that is manned, and several unmanned ships in the vicinity. The manned ship could have something similar to an SCC onboard, and also a support and maintenance team. The manned ship would then work as an extra safety and redundancy to the real SCC. If something happens to one of the unmanned ships, the manned ship could quickly dispatch a team to fix whatever problem might occur. Another benefit of this would be if one ship looses connection to shore, this could be relayed to another ship closeby, which then relays to the SCC, or the manned ship could just take over the operation completely. However, these type of ships would probably be limited to longer voyages, such as atlantic crossings. When the ships approach shore, and need to split up, a shorebased organization would need to take over.

7 Conclusions

The comparative analysis of the three Scandinavian projects showed that the projects have different views on their future shore control centre. While some have started to look at the interface and the design of the shore control centre. Autonomous shipping is in its early stages and the routines of the operators have not yet been described extensively or tested.

One of the main subjects that is discussed in projects is how to achieve situational awareness without human presence. All the projects have similar ideas on this, that this will be achieved by several sensors that fuses data and send it to shore. How this data will be interpreted differ slightly between the projects. There is the concept of the shore control centre, but the ideas on design and human involvement differs between them when discussing this. However, one thing that they agree on is that, the need for SA will decrease as the level of autonomy increases.

When looking at BRM, it has the potential to be implemented in the new work domain of the SCC. One example of this is the idea of having the operators working in teams. This paper proposes working in pairs, but it could also be teams with 3 or more operators working together controlling multiple vessels.

BRM as a concept is designed to keep the human in the loop by adapting routines such as cross-checking and challenge and response. These routines could be just as useful in an SCC setting. By placing two operators in the same room they would be able to work in a similar fashion to that of a bridge team, and utilize the ideas and established practices that comes with this. When designing future SCC concepts this area should be further explored

Bridge Resource Management (BRM) is a well developed concept, backed by many years of trial and error, experience, tradition and research. In the development of autonomous ships, this concept has been largely neglected.

When Eetu, involved in the AAWA-Initiative is asked how much they have looked at BRM his answer is “Not as much as we should have, but we had some discussions with operators of small ships and small ferries. There is some discussion, but not much detailed information from that.” This answer reflects most of the developers work in this area. There has been some implementation of bridge routines, but focus has been more on technical feasibility studies.

When designing future concepts on autonomous ships, it is important to not forget the roots of the maritime industry. It is understandable and logical that developers look for answers in innovative and leading research, but they must not forget to also look back.

8 References

Blanding, H. C. (1987, January). Automation of ships and the human factor. In Ship Technology and Research Symposium (STAR), 12th.

Burmeister, H. C., Bruhn, W. C., Rødseth, Ø. J., & Porathe, T. (2014). Can unmanned ships improve navigational safety?. In Proceedings of the Transport Research Arena, TRA 2014, 14-17 April 2014, Paris.

chalmersprofessional.se (2017, February 20), Bridge Resource Management, retrieved from: https://chalmersprofessional.se/sv/utbildningar/maritime-resource-management-mrm

Captain L.Al Holder, ExC, MPhil, FNI, FRIN, FCIT, President, The Nautical Institute, January 1994, Nautical Briefing, Passage Planning

Captain P. Boyle, FNI, President, The Nautical Institute, April 1993, Nautical Briefing, Bridge Watchkeeping

DNV GL (2015). Report No. 2015-0170, Rev. 1 – www.dnvgl.com

Eide, M. S., Longva, T., Hoffmann, P., Endresen, Ø., & Dalsøren, S. B. (2011). Future cost scenarios for reduction of ship CO2 emissions. Maritime Policy & Management, 38(1), 11-37.

Hancock, P. A., Jagacinski, R. J., Parasuraman, R., Wickens, C. D., Wilson, G. F., & Kaber, D. B. (2013). Human-automation interaction research: Past, present, and future. ergonomics in design, 21(2), 9-14.

Hontvedt, M., & Arnseth, H. C. (2013). On the bridge to learn: Analysing the social organization of nautical instruction in a ship simulator. International Journal of Computer-Supported Collaborative Learning, 8(1), 89-112.

International Maritime Organisation (2000), IMO Standard Marine Communication Phrases (SMCP), NAV 46/INF.4

Iversen, R. T. (2012). The mental health of seafarers. Int Marit Health, 63(2), 78-89.

Johnston, N. "The paradox of rules: Procedural drift in commercial aviation." Proceedings of the Twelfth International Symposium on Aviation Psychology, Dayton, OH. 2003.

Jokioinen, E. (2016). Remote and autonomous ships - the next steps.

Lützhöft, M. H., & Dekker, S. W. (2002). On your watch: automation on the bridge. Journal of Navigation, 55(01), 83-96.

Macrae, C. (2009). Human factors at sea: common patterns of error in groundings and collisions. *Maritime Policy & Management*, *36*(1), 21-38.

Maritime and Coastguard Agency, Marine guidance note, MGN 315 (M), (2006), Keeping a safe navigational watch on merchant vessels

Porathe, T. (2014). Remote Monitoring and Control of Unmanned Vessels–The MUNIN Shore Control Centre. In Proceedings of the 13th International Conference on Computer Applications and Information Technology in the Maritime Industries (COMPIT '14) (pp. 460-467).

Porathe, T., Prison, J., & Man, Y. (2014). Situation awareness in remote control centres for unmanned ships. In Proceedings of Human Factors in Ship Design & Operation, 26-27 February 2014, London, UK (p. 93).

Roberts, S. E., Nielsen, D., Kotłowski, A., & Jaremin, B. (2014). Fatal accidents and injuries among merchant seafarers worldwide. Occupational medicine, 64(4), 259-266.

Rothblum, A. M. (2000, October). Human error and marine safety. In National Safety Council Congress and Expo, Orlando, FL.

Rødseth, Ø. J., & Burmeister, H. C. (2012). Developments toward the unmanned ship. In Proceedings of International Symposium Information on Ships–ISIS (Vol. 201, pp. 30-31).

Rødseth, Ø. J., Kvamstad, B., Porathe, T., & Burmeister, H. C. (2013, June). Communication architecture for an unmanned merchant ship. In OCEANS-Bergen, 2013 MTS/IEEE (pp. 1-9). IEEE.

Rødseth, Ø. J., & Tjora, Å. (2014). A system architecture for an unmanned ship. In Proceedings of the 13th International Conference on Computer and IT Applications in the Maritime Industries (COMPIT).

Saarni, H., Pentti, J., & Pukkala, E. (2002). Cancer at sea: a case-control study among male Finnish seafarers. Occupational and environmental medicine, 59(9), 613-619.

Sea Traffic Management Validation Project. (2017, February 22). Sea Traffic Management - The next step for a safer, more efficient and environmentally friendly maritime sector, , retrieved from: http://stmvalidation.eu/

Sea Traffic Management Validation Project - Sjofartsverket, (2017a, February 22), retrieved from: http://www.sjofartsverket.se/Om-oss/Forskning-och-innovation/Sea-Traffic-Management-Validation-Project/

Sheridan T.B., & Parasuraman R. (2005). Human-Automation Interaction. In Reviews of Human Factors and Ergonomic, vol. 1, 1: pp. 89-129.
Sjofartsverket.se, (2017b, February 20), VTS-operatör, retrieved from: http://www.sjofartsverket.se/Om-oss/Jobba-hos-oss/Om-oss/VTS-operator/

United Nations Conference On Trade and Development, Review of Maritime Transport, UNCTAD 2015

Wagenaar, W. A., & Groeneweg, J. (1987). Accidents at sea: Multiple causes and impossible consequences. International Journal of Man-Machine Studies, 27(5-6), 587-598.

9 Appendix

Appendix 1, Interview Thomas Porathe, NTNU

P= Peter Barthelsson
J= Jacob Sagefjord
T= Thomas Porathe

P: Jag höll på att berätta lite vad vi gjorde här först, sen har vi kollat lite på hur VTS jobbar då, för vi tänker att de har en lite liknande roll i framtiden.
T: Vilka?
P: VTS, för de sitter och korrigerar vart fartyget ska vara någonstans. Så vi tycker att det är ganska relevant, Men de saker som vi tänkt på hittills är crosscheck och challenge and response. Så när vi jobbar som nav och co-nav så kollar co-nav vad nav gör till exempel. Så om man har i ett SCC som man har, i Munin tex 6 fartyg man tänkte sig. Om man har en som kör fyra och en bredvid honom som kör fyra. Så monitorerar man alla åtta på sin skärm. Så en är ansvarig av fyra av dem och den andra kontrollerar hans fyra, så att de crosscheckar varandra.
T: Intressant tanke, den hade vi aldrig i Munin.
P: nej, så lite det har vi tänkt på nu då för då får du med en viktig bryggrutin som finns ganska mycket stöd på att människor kontrollerar varandra lite grann ifall någon driftar bort och så märker någon att något händer. När man gör det så kan man ju få det med skift tex, att man har överlappande skift. Så då om du kommer och byter, byten är ju farliga på båtar, det är oftast då det händer olyckor när man byter. Men då under ditt byte så kommer du ha dels en med översikt som har koll på alla båtar under bytet och sen när din avbytare har gått så kan ju han ha suttit där i fyra timmar, så han vet ju allt vad som har hänt under de senaste fyra timmarna med dina båtar som han har observerat. Så i ett sånt system får du ju med… så lite dem slutsatersna har vi kommit till. Det kanske är lite tidigt för slutsatser.
T: Nej, det är en väldigt god tanke för att vi laborerade lite med det där med olika typer av SCC, det här med olika daylight-timezoner men just handover är något som vi sa är ett problem och kan man göra så så är det ju bra.
J: Tanken är ju att det alltid ska finnas någon som vet varför man gjorde som man gjorde, så att aldrig alla går hem, utan det finns någon att fråga.
P: Samtidigt då så att man själv inte observerar sin båt, så man inte själv har allt ansvar. Samtidigt då med situation room, öppnar det upp för att operatören som har koll på vart båten är och vilken situation båten befinner sig i kan gå med och vara med i situation room, så kan den andra ta över då. så det finns ju den möjligheten också.
T: Ja, precis. För det är ju så att någonstans så diskuterade vi att det troliga är att lite längre fram, i nästa steg, så har vi autonoma fartyg 99% av tiden. I princip kan man tänka att autonoma fartyg är ju liksom vinka hejdå och ring om du har problem ungefär och när de ringer så har man ingen aning var de är någonstans och så tar det väldigt lång tid. Fram tills man kommit dit så måste man ju ha dem som vet om och är medvetna hur vädret ser ut och om det är mitt på natten eller på dagen och situational awareness.
P: Du tror inte detta bara växer då, så att dem här som bara har fyra båtar var, helt plötsligt har åtta båtar var och sen sexton båtar var.
T: Det är ju naturligtvis detta som är risken och helt plötsligt kanske det bara är en person som sitter och tittar på alltihop och det handlar om att se om det är en röd lampa som lyser eller inte, man har ingen aning om vad som händer. Det är naturligtvis på det sättet att… en intressant sak som jag skulle vilja studera är dem här sjukhus-robotarna som kommer med de här vagnarna som åker omkring i sjukhus korridorerna som flyttar patientsängar och varer och såna saker. Istället för porterna som gick förut och körde. Är dem helt självständiga eller finns det kontrollrums-central för dem, för de påminner och gör massa självständiga uppgifter och åker hissar upp och ner och gör grejer, är det någon som har koll på dem eller har de en egen agenda?
P: I hamnarna också, har de kranar också som kör själva
T: Ja de har truckarna och container.. just det, det finns väl truckar som kör omannat också?
P: Ja det finns också, för då har dem ju en kontrollcenter där i hamnen som de styr därifrån.

T: Just det, så får de långa listor på container som de ska hämta och flytta dit dem.
P: Click and drag containrar. Det skulle man kunna kolla på, vi är väldigt nu. Bokat in oss på massa ställen.
J: Ska vi börja med första frågan. Vi börjar lätt. Vad är det du gör nu och vad har du gjort tidigare med autonoma fartyg?
T: I Munin projektet var jag då workpackage-leader i den arbetskretsen som skulle designa SCC då. Så där jobbade jag då 2013-2014 då när jag slutade på Chalmers. Så jag har gjort HMI och dragit upp grundstrukturen med Yemao. Sen så tog Yemao och Scott över själva uttestningen av det, så jag lämnade då men det är jag som har gjort alla skärmar och såna saker och den första studien när vi tittade på fokusgrupper och tog reda på vilken information som måste finnas till hands. Det här med sex fartyg var en siffra som bara togs i luften då, för att vi skulle ha någonting. Vi trodde inte på det som tidigare var Rolls-Royce's idé om att man bara flyttar bryggan över till land och så ska man ha en massiv kommunikation över, det sa vi att det kommer inte gå. Så Munin har jag jobbat i och nu har vi ansökt om en fortsättning på Munin som heter Raven som vi då ska ta tjuren i horn och titta på dem verkligt svåra problemen som inomskärs trafik och mycket möte, mycket interaktion med bemannade fartyg.
P: Hur går det med Raven, är det igång?
T: Nej, det är alltså ansökt och det ligger inne och vi väntar på besked. Antingen kommer det innan jul eller i vår.
J: Vilka är det som har ansökt. Är det NTNU och Chalmers och vilka parter?
T: Ja, precis. Det är MarinTek i Trondheim som är projektledare denna gången med det är Frauenhofer i Hamburg som ledde Munin projektet är också med.
J: Så flera aktörer
T: Ja, det är ännu fler folk i Raven, det är ännu större än vad Munin var. Ännu fler industriaktörer och institut och forskning.
P: Då kommer vi in på det som är vår nästa fråga och det är om vad du tänker om SA och vad du har gjort hittills för att få en så hög nivå och närvaro som möjligt när man opererar en båt
T: Ja, precis. Det där var den springande punkten. Dels så sa vi att man ska kunna ha tillgång till den information som finns ombord. Men vi kan inte ha 360 graders video, så mycket bandbredd finns inte. Men man ska åtminstone kunna… dels så var det den ekonomiska aspekten av det hela. Om man skulle hela tiden ha realtidsvideo på radar och alltihop va och videokamera ut. Så finns det en summa någonstans och det blev väldigt många tusen dollar i månaden.
P: Vi pratade med Kongsberg om det här och de hade satt en 360 grader kamera som de kunde streama på något sätt.
T: Ja, men Kongsberg då har de det här Seatech bredbandssystemet som de har ute i Nordssjön. Så det är någonting annat det, ska du streama det över satellit och betala dem priserna det kostar idag.
P: En till fråga med att minska den, vi har funderat på stillbilder.
T: Mina gränssnitt finns nog inte utlagda på Munins hemsida. Men där finns en knapp och det vanliga är att man trycker på den och man får en jpeg från radarn eller en jpeg från gyrostabiliseringsplattformen som står där.
P: Om man har en kamera som kan spåra det radarn säger, så kan man bara ta en stillbild och bara ta en bild åt det hållet. För det är enklare att identifiera något från en bild ändå.
T: De i Trondheim bygger ett datafusionsystem med gyrostab, infraröd och dagsljus videokameran som står på monkey då. Som också kan belysa med infrarött och sen så radarn. Så vad vi gjorde är att vi tog de här värmebilderna som man fick från ir-kameran och spred ut dem på sjökortet eller ecdisen och drog ut den så att badboll jag pratade om, blev lite avlång för att man drog ut den. Men den hamnade på rätt position i sjökortet och det var den datafusionen vi gjorde. Så att det fanns både live videos som man kunde ställa in och titta på om man ville och stillbilder som man kunde få. Det var den tanken, sen fanns det andra saker om SA som vi sa tex fatygsrörelser som försvinner om man sitter i SCC. Så vi byggde ett gyro så att man kunde se hur fartyget rör sig och speciellt farliga saker som slamming och greenwater on deck som man måste få indikationer på och om man överstiger vissa gränslinjer för roll och pitch.
P: Vad är det viktigaste eller farligast…
T: Vi hittade vissa fall, när man tex gör en aktion på ett omannat fartyg och man tror att det är ett annat fartyg. Att man mentalt är på en annan av sina sex båtar och gör man någonting med en båt och så är man på fel båt. Det är något fatalt som har med SA att göra. Att man inte är medveten om väderlekssituationen eller någon enkel sak som om det är mörkt eller ljust. Man är på väg in i en boj eller fiskebåt. Man måste vara medveten om deras beteende.

P: Förstå situationen man är i och andra båtar som är där. Tänkte man på att göra någon enkel genererad 3d-bild från data?
T: Ja, i det här situations rummet som vi kallar det. Så sa vi att vad man kan göra är att göra en artificiell bild av verkligheten. Har vi en platt yta och AIS-mål, så kan man lägga in ett target där va, som man skalar upp till rätt storlek, så kan man få en artificiell bild som inte kostar någon bandbredd alls, förutom ais-datan. Det här skulle man kunna tänka sig att ha en headmounted display. Frågan är hur mycket operatör är operatör är han bara en operatör som monitorerar som går igenom och kollar fartyget eller gör han verkligen, man kan ju klicka och dra i waypoints och klicka och dra i vektorer, så man kan göra manöver. Men vi sa att vi inte ska förse operatören med en minisimulator. Den biten lämnar man över till en riktig kapten eller styrman som med riktiga VRM-procedurer i en riktig brygga där man då återknyter till traditionell navigering. I ett första stadie, sen i en framtid blir det något annat.
P: Det vi försöker göra nu, det finns ju många grejor som är dåliga just för att vi är på en båt också. Som man kan undvika att ta med till land också och begränsningen på plats som är intressant. Sen hade vi, hur man utmanar operatören för att hålla honom i loopen?
T: Man kan tänkas att ha en operatör som typiskt kärnkraftverk med fötterna på bordet och kollar att lamporna är gröna. Vi sa det för att hålla operatörerna i loopen och där kommer de sex båtarna in. För det finns nämligen sex tio-minuters intervaller per timme. Vi sa det att operatören ska en gång i timmen gå in och göra en kontrollrunda på varje fartyg. Så arbetstiden fylls hela tiden av fartyg nummer 1 nummer 2 nummer 3. Då går man in och går igenom och tittar på vädersituationen, då gör man det med någon slags schema över vad man ska kontrollera. vissa saker får man larm på. Man kollar på båtar i omgivningen. Man försöker i möjligaste mån. Jag hade nog velat göra användarstudien i slutet annorlunda, jag hade velat se hur pass god situationsmedvetenhet en operatör kan ha på sex båtar, kan han skilja på sex olika fartyg direkt. behöver man minnesknep för detta, behöver man kanske något i HMI för att lägga upp båtarna i ordning. För att svara på din fråga, varje operatör tittar tio eller fem minuter varje timme på varje båt för att titta på båtens status. Så att man ser vad som har hänt, vad som har uppdaterats, lufttryck.
P: Varnar det om man inte kollat på en båt?
T: Ja, precis. Då monitoreras systemet, vi byggde också en itinerarium. Det var en skärm där man såg alla sina sex båtar och det var där man också gick in på varje båt. Där låg ju också info om att man ska rapportera in med e-post till Dover Control. Så det finns massa punkter som man ska göra som inte får hamna samtidigt på två olika fartyg. Så det krävs en massa planering då.
P: Man kommer in på checklistor då. Det går ju att göra på digital form eller röst som säger åt dig. Vi testade även headmounted display och man tappar ju helt rummet som man är i.
T: Det finns mycket sånt som… det är i princip i simulatorn, vill du ju ha förstäven så du har någon orientering av var du är. Om någon börjar skruva på kameran så vet du ju inte var du är.
P: Finns ju en som Microsoft som håller på med en genomskinlig, så att man augmenterar verkligheten istället.
T: Finns ju också där man tittar på augmented reality.
P: Nu kommer vi mer in på vad ni kommer fram på vad för specifik information som var viktig som man hade tillgång till, när du monitorerar dina sex båtar. så ser man ju basic information på skärmen.
T: 145 stycken datapunkter vaskade vi fram under fokusgruppen, med lufttryck, våghöjd och allt vindriktning osv. 145 datapunkter. Sen när man gör den här checken då, de här fem minuterna. Där är ju då andra saker, dels så får man en röd punkt som belyser att det finns något som förändrats. Då går man in och släcker den och då har man noterat att lufttrycket sjunker här med x millibar. Så att det var som en checklista på något sätt. Sen hade vi en annan situational awareness som vi sade måste till och framförallt försäkringsbolagens krav på obemannat fartyg. Status, livstid på fartyget, maskineri, varenda litet lager har en viss livstid innan den ska bytas, checkas eller underhållas på något sätt. Alla dessa små enskildheterna aggregerar ju upp till en enda stor stapel. Grön stapel innebär full redundans vad det nu innebär, i 380h. I gul bit så har du fortfarande redundans men begränsad. Röd bit betyder att du inte längre har någon redundans, men du kan fortfarande köra. Någonstans halvvägs så har du en prickad linje som talar om att det finns nödhamn där du kan gå in och få nödtekniker ombord och sen så har du slutmålet och då ska det ju vara en grön stapel en viss längd ovanför slutmålet så att du har en viss extra levetid. Sen kan du då klicka dig ner till maskinrummet, till generatorer, huvudmaskin och till olika system så du kan titta på vad är ditt problem.
P: Viktigt vore då att veta hur mycket redundans du har på dina olika grejor

T: Det blir det som försäkringsbolagen kommer kräva. Vi kräver att fartygen kommer vara fullgott med alla nivåer av redundans under så många timmar.
P: Någonting man tyckte att man inte behövde, något man kan köra utan?
T: Något som är svårt. men vad man kan tänka är ett scenario som, om den manicken går sönder. Vad innebär det för hela fartyget? Det hade man gärna velat veta.
P:Det händer ju ändå idag att man får en blackout och då kan inte besättningen inte göra något ibland för alla våra instrument är döda. Det händer ju saker fast man har människor ombord.
T: Transas berättade för mig att det hade slocknat i bryggan på tysklandsfärjan. Det var bara INS'en som slocknade, inget annat. Trots all redundans visade det sig att de hade en video splitter i en kabinett försvann, som gjorde att man kunde titta på radarn på olika skärmar. Och den hade en strömförsörjning och den strömförsörjningen var inte kritisk. Det var den som gjorde att alla skärmar slocknade.
P: Den gick inte på nöd strömmen då.
T: Exakt, utan den satt på någon vanlig förlängningssladd som någon hade satt upp.
J: På tanke på navigation, vad är den viktigaste informationen för en operatör?
T: Jag tror ju så här. skepparn kräver att Mona Lisa STM. Någonstans ska collision avoidance vara färdigt i förväg. Det är ett annat system som snurrar någon annanstans som hela tiden trackar fartyg och varnar och ser till. Den routeplanen man lägger, vi tänker att 99% av tiden är autonomt. Eller dumt fartyg, för den går bara i trackmode. Sen är det andra system som ser till att tracket hela tiden håller undan för lågtryckscentrum, andra fartyg. Så finns det som en backup som vi egentligen omannade fartyg, som AI, som tolkar här finns fiskebåtar och andra saker som vi ska väja. Men själva navigeringen görs egentligen iland innan.
P: Jag tyckte det var bra med redundansen. Det gäller navigationen också, vi vill ha redundans där också.
T: Det värsta som kan hända är att man tappar kontakten. Att man inte vet någonting. Då litar man på fartyget en viss tid, man kanske räknar med att fartyget i nordatlanten klarar sig i ett dygn, i engelska kanalen så kanske det inte klarar sig fem minuter. Då måste vi gå in i safe-mode och börja hovra eller något sånt där. Det beror på, för har man inte kontakten, så vet man ju inte heller om fartyget fungerar.
P: Med redundansen då. Om vi säger att det händer något med radarn då, så den går upp på backupen, går den upp på gul då på just radarn då så att man inte har redundans på radarn längre. Man har ett system som larmar från att redundansen hoppar ner ett steg.
T: Precis, det kanske är så att två radarskärmar inte räcker. Man har fyra olika radarsystem som är oberoende av varandra. När det gäller många saker och redundans nivån den påverkar den här beräkningen som visar. När den går över från grön till gul är ju beroende av hur många nivåer av redundans man har. Man kanske har fyra radarsystem, så går ett system ut så kan man fortfarande vara med på grön, men går två ut så går man ut på gul. När man bara har en kvar så är det röd va. Frågan är när det sista systemet går ut vad gör man då, stannar vi fartyget och låter det driva då om det är på fartyget och skickar ut en bogserare, det är alla dem här överväganden som kommer sen. Det kommer säkert bli en massa nya business cases, som salvage companies och får igång dem på nått sätt. Ny framtid.
J: Vad är mest fördelaktigt och nackdelar med att vara i land istället för till havs?
T: När vi började med Munin träffade vi många studenter och vi räknade med mycket motstånd från er eftersom det är era jobb på något sätt. Men vi upptäckte att folk var ganska intresserade av det här. För det är klart att bemannade fartyg kommer inte försvinna, utan det är en ny typ av fartyg, men en ny nisch. Många fartyg kommer fortfarande ha bemanning.
P: Men nackdelar/fördelar med att köra från land gentemot sjö?
T: En fördel är ju efter några år till sjöss känner att det är dags att bilda familj, gå iland och ta ett kontorsjobb, så kanske man kan fortsätta köra båt i ett kontrollcenter. Så det finns nya typer av jobb som kommer till. Och det här med salvagecompanies som kommer är nya typer av jobb som kommer till. Min bror var kapten på ett oljefartyg och han sa att det blev ganska trist, man är i en plåtburk och man hinner aldrig gå iland. Ibland när han var på bryggan så blev styrmännen nervösa. Så han kunde inte vara på bryggan så småningom heller, det blev skittråkigt för honom. Man kanske kan flytta in roliga jobb.
P: Tror du man kan ta hem massa jobb också? För nu försvinner många jobb till utlandet
T: Intressant fråga, vilka är det som kommer bli operatörer och hur ser de typen av jobb ut? Det kan ju hända att Maersk sätter upp en central i Köpenhamn där de driver hela sin flotta. Så sätter de operatörerna där också och Wilhelmsen då i sverige.
P: Internetkopplingar är snabba idag så man har ett sätt att jobba utomlands också.

T: Vi sade ju att det finns många olika typer då. Det kanske finns ett kontrollcenter i engelska kanalen som tar över alla fartyg. Eller att varje rederi har sitt eget kontrollcenter eller att bemanningsbolag har kontrollcenter som man hyr in sig i, är det så att VTS har någon kontrollfunktion. Tar VTS Göteborg över alla fartyg utanför Trubaduren? Det finns många. Och det här som jag tror är att man jobbar drägliga arbetstider, man jobbar kontorstider, istället för nattvakter och sånt.
J: Vad är nackdelarna med att jobba iland istället för till sjöss?
T: Visst, det där romantiska med att se världen och sånt, men medelåldern för sjökaptener som går iland sjunker ju hela tiden.
P: Vi kom in på det här med arbetstiderna och fatigue. Vi har ju båda varit i stormar och varit sjösjuka inte kunnat sova. Det är ju trevligt att man har en viss kontroll av fartyg, första dagen liksom men sen får man ju en sämre SA om man är på plats.
T: Det är en tanke som vi inte tänkt på. Men just att man har svårt att sova om det rullar. Man blir kanske avtrubbad på ett sätt därefter ett tag. Det är något funderar jag på hos Estonia, jag undrar varför dem kör, dem känner väl i kroppen att dem kör sönder fartyget att de ligger och slår in i vågorna hela tiden.
J: Ett fartyg ska ju klara av att stå och stampa i vågor hela tiden, så man tänker inte på det på samma sätt.
T: Jag vet när man är ute på fritidsbåt, en viss stampning funkar väl. Men bottenslagen känner man att man får sänka på farten.
J: En storm kan slita på fartyget som ett års vanlig drift. Det tar illa, men fartyget ska ju klara det.
P: Jag tänker när jag sitter där, kan jag se hur mycket stress fartyget upplever, det finns ju sådana sensorer. Då kan man prova om man är i land att ändra lite kurs och så och se hur stressnivåerna går ner. När man är på plats så vill man ju inte vara där.
T: Det var något vi diskuterade med en person om, om man har stänger på däck som mäter spänningar och sånt. Det finns ju sensorer som mäter sånt.
J: Hur viktigt är det att ha en människa i kedjan av automation istället för helt automatiserat?
T: Man kanske kommer till en fullt automatiserat system så småningom men under väldigt lång tid kommer man vara beroende av den erfarenhet som folk som varit ute till sjöss har, för de automatiserade systemen är inte klokare än hur vi programmerar dem. Det är en utveckling som måste ske, vi måste göra systemen ännu smartare och det är möjligt att man kan använda en maskininlärning i detta. Men i början är det väldigt viktigt att vara med och titta och förstår och tolkar, och att det är människor som varit till sjöss som vet hur den här typen av väderleks system påverkar skrovet och alla såna här grejer. Och förstår andra båtar, interaktion mellan automatiserade båtar och vanliga, för där kanske den största utmaningen finns. Fiskebåtar, hur beter dem sig? Som olyckan jag nämnde igår i engelska kanalen, dem tittade inte ut ur rutan, för att de litade på att alla andra håller undan. Men de fiskade där på något sätt.
P: Hur designar man ett system som är anpassad för användaren?
T: Nu är det ju bara en guideline då, IMO User-centered Guidelines. Vi hoppas ju på att det blir ett krav snart och inte bara en guideline. Det är ju det att användarna ska vara involverade i designen redan från början. Det är ju då vår förhoppning att det ska innebära att om ett system är baserat på användarstudier, testat iterativt under utvecklingen och är utprovat på användare i slutet. Förhoppningen är att det ska vara ett sorts garanti för att det ska vara användarvänligt. Man kan ju skriva att det ska vara användarvänligt, varje fabrikant säger att deras system är användarvänligt. Alla som använt transas i flera år tycker att det är väldigt användarvänligt, de som kommer från Furuno blir ju galna för att de inte förstår hur Transas fungerar. Där har det med standardisering att göra. Det är den svåraste biten, för industrin vill utveckla fritt och finna innovationer och vill tjäna pengar på en ny gadget som är jättepopulär. Samtidigt kommer det system som plötsligt en dag byter ni fartyg och ni har 50 min innan avgång och så får ni ett system som ni aldrig sett förut, vad vi hör är ju att brukarna bara använder toppskiktet av alla finesser som finns av radar och ecdis, för du hinner aldrig lära sig, har tid eller ork att gå ner och lära sig alla finessar av det hela. Ni har läst om den här Ovet-olyckan, de hade ju planerat kursen rätt över Vanbank, sen var systemet i defaultläge, så safety curve på 30 meter. så hela engelska kanalen var mörkblå. Alarm Porten var aldrig konfigurerat, systemet hade aldrig någonsin alarmerat. Då är det något fel, då har man byggt ett system som är så komplext, så ingen orkar bry sig att använda allt det där som finns för att man inte ska gå på grund.
P: ECDIS finns det ju alldeles för mycket alternativ på. Man pratar lite idag om att göra standard-ECDIS, kommer nog fortfarande bli väldigt mycket. Men jag hoppas att man tänker på det då.

T: Jobbade med Kongsberg för två år sedan med ett projekt. De märkte att deras DP system. Den en-veckas kursen som de hade räckte inte till, utan de behövde två veckor. Det kostar ju pengar för rederierna och då blev dp-systemet dyrare för att utbildningen är lika dyr som systemet nästan. Då tänkte de att de måste titta på användarvänligheten. Man kunde konfigurera displayen precis som man ville, det fanns miljoner då va. Det måste bort. Det ska vara enkelt. Men de säljer ju då på sina finesser.
P: Vi kommer in på övertro att man förlitar sig på systemet.
J: Hur kan man jobba aktivt med att ligga mellan over och under-trust.
T: Det finns en teknisk nivå, där du som operatör aldrig berör. Hur vanligt är det att den här säkringen går eller allt blir svart. Det är svårt att veta. Menar lite det här med Workload Management. Om användarna går med på det systemet plötsligt. Vad skulle du tycka om systemet om det föreslår för dig att nu har vi fyren här, nu är det bra tillfälle att pejla. Då får man en känsla av hur bra gps-positionen är gentemot manuell. Om systemet säger kolla ekolodet, då lär man sig undermedvetet att man kan använda djupsiffror för positionsberäkning, enligt min känsla är väldigt få som tänker på. Då kanske man kan lära sig lite om over och under-trust. Om man kollar på Honda Point, 1923 med radio pejlingen. Om man i dagsljus radiopejlar och jämför med död räkningen, så får man ju en förståelse av hur mycket man kan lita på ett system och när man inte kan lita på den. Det kan på ett sätt hjälpa till. På samma sätt som att jag föreställer mig att en operatör kanske ser att ett fartyg inte är kurs stabilt, headingen stämmer inte riktigt. Man får en kunskap om saker.
P: Tänker konkret att man slutar lita på larm, när saker larmar för mycket.
T: Det har vi pratat mycket om, med tillverkare. För de är tvungna att larma om vissa saker, GPS’en går så larmar 78 instrument, hade varit bättre med ett larm. Men då larmar Radarn, men det måste larma, står i regelboken. Lättare sagt än gjort, hur många falsklarm kan man ha innan man riskerar att missa ett riktigt larm.
P: Fused Alarm System tänker jag, att man har ett OS för alarm.
T: Volvo-bilarna har gjort så att vissa larm stänger av om man kör fortare än 100kmh. Det borde man ta efter i sjöfarten.
P: Hur mycket har ni kollat på existerande bryggrutiner när ni designade SCC?
T: Vi undvek frågan genom att introducera Situationsrummet. Vi sa att operatören är operatör som bara tittat så att allt fungerar. När det blir problem, nav eller maskin, så övergår det till en normal brm i situationsrummet eller en maskinist som har tillgång till andra rutiner.
P: Då tänker ni att operatören inte ska ha någon mer kunskap än att veta vart lasten ska.
T: Det är lite suddigt, för där har vi har lagt in rutiner i operatörens roll så att han kan ta indirekt eller direkt kontroll. Operatören måste kunna ta kontroll för att undvika fiskebåtar, men kör man in i Malackasundet så kanske det inte är operatören utan det går över till situationsrummet där det finns en pilot och co-pilot där brm gäller.
P: Vi körde vår uppkörning nu för några veckor sedan. Då fick vi 20 minuter att förbereda och hoppa in i en situation, då känns de 20 minuterna väldigt snabba, även för styrmän, då är det liknande att fast man hoppar in i en situation utan någon förberedelse alls.
T: Du hade en punkt med det du sa förut, att operatören går in i och är med i situationsrummet. I den uppställningen vi sa på rummen så sa vi att om en operatör får problem med ett fartyg blir han befriad av sina andra fem fartyg. De läggs över på ett annat ställe, så han kan lägga hela sin tid på situationen och då bör ju han också vara med i situationsrummet.
P: Som navigatör får vi också en viss uppfattning om trafiksystem i olika delar av världen. Vi vet var båtarna brukar komma ifrån och var separationerna är. Vi vet ju det från att vi har planerat rutten, vi känner att den biten är viktig.
T: I början tror vi att det är ett sjöbefäl som har operatörsrollen. Sen är ju frågan hur robust är systemet, hur mycket collision avoidance och det som du pratade om läggs över på ett STM-system. Är det så att man inte behöver tänka på det längre, för att Sea Traffic Management har redan löst dem här problemen att det kommer båtar från andra håll redan. I slutet av MUNIN-projektet hade jag velat testa det här, köra det här med operatörer med 6 båtar på en eller två stationen, för att få en känsla hur man upplever det här och läsa av fartyg. Tid efter annan och oftast händer det ingenting.
P: På en brygga har du ju en viss setup, en bridge setup, hur man ställer in saker. Varje operatör kan ju ha sin egna setup. Men har ni kollat hur man sätter upp bryggan på en båt och sen hur man sätter upp en kontrollstation på land. Har man tagit med grejor?

T: Den designen jag gjorde på HMI, vi sa att vi hade fem skärmar här nere. Radarbild låg inte uppe, utan den får man beställa hem från fartyget. Utan vi hade fusionerade bilden, Datafusion, egentligen ett ECDIS, som lägger upp mål som radarn har hittat men av form av en symbol eller något, som hämtar hem info från infraröd kamera, för den infraröda kameran går också på fartyget hela tiden och larmar om den upptäcker någonting. Operatörens sjökort eller ecdis är en fusionerad bild som operatören har, det är då huvudbilden. Det var inte så att vi hade conning och radar, utan huvudbilden var då itinerariet, planeringen som talar om, du har tidslinjen här och så klickar du in i varje fartyg och så får du upp dem skärmarna för det fartyg. Så den enda översikten du har för varje fartyg är den här gröna lampan som är mitt i den där cirkeln. Den gröna lampan talar om att alla system är go och det finns inga faror som automationen kan upptäcka.
J: Och så kollar man noggrannare en gång i timman på varje båt.
T: Ja, men det är klart, ser man att man är på väg in i ett gäng fiskebåtar. Då måste man naturligtvis göra någonting. Då handlar det om att man förmodligen måste sätta sig med det här fartyget och lägga bort de andra fem fartygen.
P: Kanske till och med kommunicera.
T: Ja, kanske det och hur ska det gå om man säger att man har, i värsta fall, åtta sekunder delay med VHF. Om man ska ha VHF mellan båtarna och sedan satellit mellan båt och SCC och sedan tillbaka igen. Vi gjorde något projekt med isbrytarna i Bottenhavet, de sa att när de är utanför området för VHF och gick över på satellit med Sjöfartsverkets basstation. De sa att det inte var möjligt, det gick inte att föra ett vettigt samtal på dem premisserna, om det ska gå fram och tillbaka på satellit. Man talar ju på satellittelefon med Australien och sånt och det går ju alldeles fint, vet inte varför, men det går ju också på två håll.
P: Jag ringer Nya Zeeland ganska ofta och det går ju bra.
T: Förstår inte varför Isbrytarna har problem.
P: Det kan ju vara något med polcirkeln där också att det behöver studsa på en landstation.
J: Det beror väl på vad du har för instrument på fartyget också, du har ju en bra antenn iland.
P: Det måste ju vara en flaskhals någonstans, jag ringer ju bra till Nya Zeeland.
T: Det var ju ett frågetecken vi satte, kan man ringa upp på VHF om man sitter på en landstation på andra sidan jorden?
J: Hur är tanken att ni ska bemanna Situationsrummet och konfigurering runt den?
T: 100 fartyg måste SCC kontrollera för att det ska löna sig, framförallt för underhålls biten och navigations planerings biten. Det är ju kontorsavdelningen som sköter det. Navigations Avdelningen som planerar rutter, kopplar till STM och den biten. Maskinsystemet måste planera underhåll, var ska man byta ut saker som slutat fungera, var finns reservdelar i världen, hur ska man komma ut med saker. Det är ju tunga bitar i det hela. Sen var det hela operatörsrummet då, tre olika stationerna med trettio båtar i varje. Och ett situationsrum, som är nästan oanvänt, enbart är till för nödsituationer. Vi räknar med att fartyget går 99% autonomt. Antingen i form av track following mode eller AI. Det är bara 1% eller mindre där operatören måste gå in och ännu mindre då det är krisläge och man måste fortsätta in i situationsrummet.
P: Ni hade räknat med lots kustnära.
T: Ja, vi undvek hela det problemet med det som vi ska titta på i Raven, fartyget är bemannat med lots och relief-crew ut till Trubaduren och gå oftast omannat, man kan ju gå med folk på båten. Sen så kommer lots och besättning ombord igen vid lotsplatsen vid destinationen. Det är ju inte syftet i långa loppet, men det blir ju ännu större problem, hur går vi in i skärgårdar, hur ska man hantera havskajaker, fritidsbåtar med oerfaret folk.
P: Raven är det NTNU och Chalmers?
T: Ja, båda är med. Tanken är att jag ansvarar för just den biten med interaktion mellan bemannade fartyg och framförallt fritidsbåtar. Det ska vi försöka köra i simulatorerna här. Får vi Raven så kör vi igång nästa år.
P: Vad ser du om framtiden, din vision?
T: Det är intressant att se Rolls-Royce som sitter på pengar, men de har hoppat direkt på dronerna. Finns ju många andra varianter som inte många kollar på, som platooning tex. Jag tänker på Gustaf Eriksons koncept, känner ni igen den?
J: Var det han som köpte upp alla segelbåtar?
T: Han köpte upp alla järnseglarna, så han seglade på barlast ner till Australien under våren, under vintern, när det var sommar på Australien lastade han vete så hade han 3-4 månader tillbaka och då kom han tillbaka till Europa när vetepriserna var på topp, för förra årets spannmål var slut. Så sålde han och tjänade stora pengar. I bästa fall fick han några veckor semester på Åland innan det var dags igen. Besättningen bestod av Apprentices

som betalade för sig, för de var tvungna på den tiden att ha praktik på segelbåtar. Så han hade bara en liten del lön att betala. Så på något sätt hade man kunnat tänka sig att omannade fartyg jobbar, går på löpande band till Australiens gruvor, kanske går driver i strömmar, kanske tar flera år. En sak är containertrafiken i Japan där det är högvärdigt gods som ska fram fort. Men lågvärdigt gods som man inte behöver direkt. Men man alltid behöver det.
J: I MUNIN, hur ska man få en direkt SA när man tar över ett fartyg i Situationsrummet?
T: Bra fråga, för det innebär i praktiken att man helt plötsligt slår på alla systemen. Om man är kapten och styrman som kommer in och inte har någon aning, man vet inte ens vilken världsdel man är i, operatören måste ju gå in. Då är frågan vad är de här operatörerna, i början har vi sagt att de är Sjöbefäl. Då är det naturligtvis dem som går in, för de har situationen och får då bättre SA för att det ser ut som en traditionell brygga och en co-pilot, man får rutiner som man är van vid. Men hur ser det ut i framtiden sen? Om det obemannade systemet är så robust att det bara är en gång om året man måste gå in i situationsrummet, då kanske man kan säga att man tar den risken att det tar 30 min att få SA. Kärnkraftsindustrin, alla olyckor, Chernobyl, Harrisburg, även Fukushima beror ju på att larmet går och folk kastar sig på knappar och vrider på saker. Därför är grundregeln på kärnkraftverk nu att när det stora larmet går, sitt på händerna, ta en kopp kaffe och gör inget på 30 min. Bara försöka titta och förstå situationen. Kan man tänka sig något sånt på fartyg?
P: Jag tänker att det har hänt många olyckor för att man gör ingenting till sjöss. Man har inte tid, man blir stressad, man tar inget beslut. I vissa fall så har man tid, men många fall har man inte det. Man får ett larm för att man har hamnat i en situation som är svår att lösa.
T: Det är ju sant, har man en triple-e utanför så kan man inte sitta på händerna. Då är frågan hur ser backup, de här SCM-systemet, hur väl utvecklade är de?
P: Jag tänker att om man är lite längre fram, så kanske man får alternativ så kan man välja en av dem.
T: Så kanske det kan vara.
J: Hur känner du om att ha färre besättningen ombord istället för fullt omannat?
T: De flesta kollar på den färdiga biten, men jag tycker det intressanta är vägen dit. Vad kan man göra för att komma dit. Som en sak att man är på Nordatlanten klockan 3 på natten och det finns inget eko på 24nm skalan. Kan man inte lägga sig ner och ta en 15 minuters paus i soffan, samtidigt som man ber någon i land att kolla lite på radarn. Kan det vara det första lilla steget. Kan man få IMO att godkänna det? Eller engelska kanalen, navigatören är på bryggan, utkiken är på bryggan. Men måste kapten vara på bryggan eller kan man be någon i land att supporta och sitta med huvudet i radarn så att man kan ägna sig åt att kolla ut ur rutan. Kan man få en skärm som sitter i co-pilot stolen som man kan titta på, där sitter min kollega fast han sitter i Göteborg istället. Så kan man snacka med honom och diskutera om läget. Är sådana lösningar möjliga?
J: Tänker ju även VR och sånt.
T: Wilhemsen sa ju att det sitter fyra fleet managers i stockholm på Wallenius som tittar på Weather Routing och tittar på sjö.. Något som är oerhört roligt, att skriva ett program som följer COLREG är ju enkelt. Men verkligheten ser ju inte ut så. För kör man ut ur en situation, så kör man in i en annan och alla beter sig inte korrekt. Att kunna följa ett fartyg under en period där man har ais-loggen, radar-loggen osv. men fortfarande får kommentarer från bryggan. Det hade varit utmärkt information för de som ska skriva anti-collision program och inte bara tolkar colreg. Sen sa han på Wallenius att Weather Routing är inte alls så bra som man tror, ungefär vartannat år kvaddar man en hel last med bilar för att man går in dåligt väder fast man har Weather Routing från två bolag.
J: För att runda av, är det något du vill peka på om något som vi pratat om?
T: Det ni tog upp sist, det finns mycket fokus på det färdiga. mellantinget, de här sakerna som vi kan tjäna lite granna på. Jag säger inte nödvändigtvis att man ska nerbemanna. Fartyget kanske inte är obemannade men är autonoma ändå. Det kanske finns andra uppgifter ombord man gör på fartyget. Det handlar om två saker, att man ska transportera gods och att det ska vara säkert. Drivkraften är ju att det inte ska kosta liv. Nu kommer det kanske förekomma ett drivande fartyg som man måste åka ut och hämta, i en helt annan utsträckning än nu. Men är man inte trött och fatigue på bryggan utan kan sitta i land, kanske det blir bättre beslut i slutändan.
J: Vi har också tänkt lite på stegvis utveckling, som platoneering eller att köra i par.
T: Offshore i Norge, den här transportsträckan ut till fältet kan vara autonomt och så kommer besättningen ombord när man ligger och gör det här komplexa arbetet. Sen går man ombord på plattformen igen och så kör båten autonomt tillbaka till land.

P: Vi har tänkt lite på lastbilar också och deras konvojtänk med bemannad lastbil längst fram där andra lastbilar följer. Har ni tänkt på det?
T: Det pratas väldigt lite om alternativa lösningar. Det har dykt upp lite om flockar eller platooning.
P: Det är ett hett ämne nu.
T: Det är ju det, teknikindustrin ser att man kan utveckla nya sensorer och här kan man tjäna pengar. Det är nog därför det är mycket fokus på det.
P: Det har ju alltid gått en stadig kurva med mindre och mindre besättning ombord, den kurvan har ju planat ut nu.
T: Något annat är ju underhållet av fartyget. Vem ska knacka rost. Det var ju på 70-talet där de sa att man skulle sluta knacka rost och lägga fartyget på varv. Men det funkade ju inte.
P: Wallenius sa att deras båtar klarar 35 dagar helt underhållsfritt om det inte händer något. Maskineri och allt.
J: De nämnde även att någon på Volvo hade sagt att större fartyg är inte byggda för att vara underhållsfria. Tekniken finns för att bygga fartyg som kan vara underhållsfria.
P: Underhålls schemat är ju anpassat för att det är folk ombord, att vissa saker ska göras varje månad eller varje vecka. Men man hade ju kunnat sätta in en grupp människor som gör allt det här underhållsarbetet när fartyget är i land.

Appendix 2, Interview Hans Anton Tvete, Senior Researcher, DNV GL

P= Peter Barthelsson
J= Jacob Sagefjord
H= Hans Anton Tvete

P: Our thesis is focused on the shore-side of the operation, we are not sure exactly how much you have worked on that on the ReVolt project. So we are looking on how the future vessels will be controlled, if there will be an operator, how they will work. First question is what have you worked with regarding autonomous vessels and what are you working with right now?
H: How we started on this topic was with the ReVolt concept study, it is a concept study, i have to emphasize on that. We launched back in 2014, we kind of philosophically talked about the unmanned aspects, so that started us off. After finishing the ReVolt project, which got a lot of attention in the industry. We continued our work in different projects, we participated in AAWA. They have a broad take on autonomy and we are in there to offer some advice on the regulatory side as well as to learn more about the technology. We have been heavily involved in a project in Norway called AutoSea, project run by NTNU, the norwegian university of science and technology. The plan is to educate three phD students and also a post hoc and several master thesis students on this topic. There is a focus on sensor fusion, target tracking. So the navigational side. We are in it to learn more about that. Our main focus as a classification society is of course to build rules for these kind of ships, rules considering autonomous ships. That is what we want to do and we want to be able to serve our customers, at least help them to put those kind of ships in the water in a safe and reliable matter.
P: We looked into AAWA and we also talked to Thomas Porathe and we heard you talking at Chalmers SJÖLOG 2015. We are getting into a bit of the work on the SCC's and are wondering if you ever thought about SA onboard these vessels.
H: We wanted to take ReVolt to full autonomy basically, so no remote control. AAWA Is much about remote control. but we wanted to restrict the boundaries as far as we could and let the ship take all the decisions by itself. That does not mean that it will not require any shore-side support in a case of emergency. I think that, both remote-controlled ships and fully autonomous ships need the other solution as a way of fail-to-safe backup. So if something happens with the remote-control connection, then there should be some autonomous functions onboard to make themselves sustained in case of something happens. The same goes the other way around, if something happens with autonomy, someone from shore should be able to take over and help out. In the ReVolt project we focused on fully self-sustainable ship.
P: So you have been looking into having a lot of redundancy in all the systems.
H: Yes, the battery propulsion is very interesting, we have our battery room split in two in case of an emergency like that. It is a very low maintenance requirement for those systems. Low maintenance need have very much been a focus on the concept development. The propulsion system is built up to have DP capability and you have 2x 360 degrees pods in the stern for main propulsion and you have also a 360 degree pod as a bow thruster. So all in all, we tried to lower the maintenance need and build in redundancies.
P: You said that there will be some kind of operation on the shore system, but do you plan on having any systems, like camera, radar pictures for the operator to get, or whoever is watching, just like a VTS service or anything.
H: We haven't given much thought of the how the interface to the potential shore operator will be, whether if its cameras or if its radar. It's likely that it will be cameras, of course. Cameras can also be employed not only in the case for the operator on the shore to see, but you can also employ cameras for object identification as well. It's cameras, radar, AIS, LIDAR and IR-cameras. It's gonna be a variety of sensors and the information from those sensors will be fused together to form a reliable situational awareness around the ship, as well as to build in redundancies. The Norwegian Maritime Director also said that this is most likely to happen, you have to have redundancies on sensors as well, you can't rely on a single sensor to navigate your ship safely.
P: I guess you have to have a lot of more redundancies on an autonomous vessel.
H: Yes and with the captain on board or a naval officer on board is also some kind of redundancy. I think that's also how the engineers, you know for instance a ship with one Main Engine, there's no technical redundancy to that, if that engine breaks down, you are basically floating in the water, but the engineer is regarded as redundancy or a backup.

P: The ReVolt projects plan is to run close to the shore, right?
H: Yes, that's right. For several reasons, one is to transfer more freight from land to sea, to expand the short-sea shipping, to build a cost effective alternative there. We also believe that the first rules for these ships will be built out in territorial waters. The flag state dictates.
P: The MUNIN project researched more oceanic travelling, but I think this is more relevant, because IMO is very hard to prove things to. I just have a short question on the sensor fusion. Have you thought about land based cameras/lidars?
H: We are also involved in a small project with NTNU, a small bicycle and passenger ferry over a canal in Trondheim, they are actually looking into placing the radars on shore, rather than on the ship. Since its in a short sea setup, it can work. Same goes with communication system, you can have more terrestrial communication channels as well. In Norway we have a 3G mobile network called Ice.net. That kind of spreads out a little bit further out on the coast. So you can have this kind of coverages and not only rely on satellite.
P: What do you think are the pro's and con's of having personnel on ship versus an automated ship?
H: Being a sailor is a dangerous occupation, if you look at accident statistics, you can't argue your way out of it. Taking people of the ship, will of course improve that in itself. There are also different accident statistics that say that up to 80% of accidents are cause of Human Error and these are errors that can be reduced, because of fatigue, you don't have that with a computer or machinery, they don't get stressed or homesick. Automation has the potential to mitigate some of these consequences. We looked into aviation, for example and there is more and more automation that has gradually been phased into that industry. We see that although there have been an exponential increase of passengers, accidents have declined. There is a potential there for increased automation that will be beneficial for safety and that is of course our focus as a classification society, that has been our core business for 150 years. So we are all about fusing these systems into a safe and reliable manner. And it can also be a problem in the interface between unmanned ships and manned ships, how do they act on each other. Various manned ships could agree to pass starboard/starboard for instance, unmanned ships could be very rigid in this respect and could cause unwanted situations. There is still a lot of uncertainty on the cost side of it, whether it's a financially attractive solution. In many cases, crewing is not the most expensive component on board, in Norway it is one of the most expensive component on board, in other places not. There is a crew shortage in the world, especially qualified crew. There is an increase in global trade, so that plays an important role. Ships are gonna be out there, this is not a technology that can fit every ship type. Some segments are more attractive than others.
P: I'm going back a little bit to humans, how important is it to have humans as part of the automation?
H: I think it is important, whether it is shipping or land based industry, general society, we see an increase in automation and it's about making life more comfortable for the people, so people has to be a part of the loop. I'm a technology optimist, but it has to be in the interest and the benefit of the people. You don't build a ship because of technology, you build a ship to satisfy a transport-need.
P: Have you done any work on the SCC or how they are designed?
H: No, not really.
P: Im curious on some more technology on ReVolt. In regards to battery, when you spoke two years ago, you were talking about lifting batteries from the ship but now you are more into charging?
H: Yes, battery technology is rapidly evolving, improving energy density and lowering costs. In ReVolt we ended up with fixed batteries and charging. We believe we have such an operational profile that it will benefit the lifecycle of the batteries we have. We have a big battery and average a very low power outtake of that battery. So the battery is quite big to serve the worst case scenario where it is bad weather. On average you have very shallow charging. You could substitute batteries with batteries in containers, it would be very fast to change this. It would require less shore power and charging infrastructure, but then you would need to have a lot of batteries standing around and that would be capital intensive. So all in all we believe that the best solution was just to keep them on board, charge them and replace them around halfway through the lifetime of the ship or something.
P: So you would be able to lift them up from the ship?
H: Yes or drag them out of the side of the ship.
P: Is it lithium batteries or are you waiting for something better?

H: Lithium Ion batteries, there are of course different chemistries under the lithium ion umbrella. Some are for more energy demanding purposes and some are for durability. There is a lot of research going on in batteries, which is exciting.
P: I guess you don't really need a quick output but you need to be able to charge the batteries pretty fast.
H: Yes, on average that these comparable ship types stay for port is around 8 hours, that is more than enough. The ReVolt said that we can hope to bring down the time in port to save some cost. But 4 hours is are well within the low voltage for the shore power, so you can use existing shore power, low voltage infrastructure for a ship like ReVolt. Which is beneficial, because you don’t have to invest in a lot of extra equipment.
P: Is the NTNU’s ferry gonna be battery powered as well?
H: Most likely.
P: Im curious also on the mooring operations, if it will be magnets or lines.
H: We went for a vacuum based solution, that is also something like Wärtsilä and Cargotec, they have developed a new inductive charging solution, combined mooring and charging solution. So you just have plates going into the ship side, mooring them and charging them at the same time.
P: Can they move?
H: These vacuum plates can go in and out of the part and they are typically fixed on rails in a height direction, so they can go up and down on the jetty.
J: What would be the biggest challenges right now for autonomous challenges in general?
H: The challenges for many owners right now are oversupply or tonnage, rates are low. There is gonna be more and more environmental scrutiny, for shipping. Shipping was left out in the COP21 agreement. I think it is gonna be escalating. The EU MRV scheme is coming, the co2 reporting scheme. IMO is working on something similar. I think it could be more focus on shipping to lower its emissions further. Not only local but also co2. That is also a challenge. To find out what kind of fuel will be used, going forward. Availability and sustainability of the fuel and of course environmentally stable. Ship owners will have to adapt to solutions and follow the race with cars.
P: I'm curious about how the ship will act on different legs of the journey, because MUNIN wants to slow-steam, with battery driven vessels what are you thinking about the speed of the ReVolt vessels?
H: The ReVolt vessels are also very low, transit speed will be 6 knots. With the route and operational profile we chose it's a prerequisite to have a low energy demand on board. It works in a short-sea context, it will not work on oceanic transits, not today at least. We had the same approach, to increase the number of ships to maintain capacity in the logistics-chain, that's how we envisions it.
P: How far can you go before you have to recharge?
H: 100 nautical miles.

Appendix 3, Interview Eetu Heikkilä, VTT

P= Peter Barthelsson
J= Jacob Sagefjord
E= Eetu Heikkilä

P: What have you done previously and what are you working with right now concerning autonomous vessels?
E: For autonomous ships I have worked with risk management, so I have been looking on the safety risks related to this new technology. We are moving towards practice now regarding the qualification of autonomous ships, so we are laying out practical requirements for the safety issues for those ships, that's what I am doing right now. I'm also involved in a few other projects, so I'm not totally focusing on the ships.
P: Is there any similar projects you are working with that is relevant for autonomous ships?
E: Yes, we are working a lot on different levels of automation, It is about how we can prove and show that autonomous vehicles are safe.
P: What do you think is the major benefit of automating ships?
E: Beneficial for the safety, because a lot of errors are human errors still. In similar fields we have seen that an increase in automation increases safety significantly. We have to make sure that it happens that way. The other thing is a social issue, we can get people out of places they don't want to be.
P: Is there any cons of automation of ships?
E: Of course, how do we control these things, they are completely new and they are so complex that it is difficult to understand if it's doing what it is supposed to be doing. Then it is the cybersecurity-issue of course, making sure the vessel is not hijacked. The biggest concerns are related to the security side. There is always a sort of learning curve, maybe the first iterations may not be safer than the current, but that is how it works with technology, we have to develop and try it out to make it better.
P: How safe can you make an autonomous vessel in regards to cyber-security?
E: You cannot make it completely safe, it is unachievable. The technology exists so that we can make it reasonably safe with reasonable resources. The development needs to be focused so that it takes into account from the beginning.
P: You can make it safe enough?
E: I would say so. There is no bulletproof way.
P: What exactly are you concerned about in regards to cyber-attacks?
E: Major disaster scenarios would be hijacking of an oil tanker and drive it ashore, but I don't see it as a very possible scenario. I think for example bringing down the data connection, so that we don't know where the ship is, that is already quite a big risk. That is one of the big problems, these ships are so big and heavy that they can create great damage even if they are just stopped or put out of control, even if there is no planned attack.
P: Your thoughts on situational awareness and what you have worked with so far to achieve a high level of situational awareness as possible?
E: Maybe the most important thing here is the redundancy, we know that there are sensors that are capable of producing the needed situational picture, but how reliable they are and how they work in this kind of environment, I think that is the question here. I see it more of an optimisation issue, so that we need to optimise the systems that already exist in the maritime world and another thing is the data stream capabilities, so if we have a ship we can't a lot of data in and out. So we need to think about what information we can provide to the remote operator.
P: Do you have any specific thoughts on the Operator's station, what will be done there to make the operator be in the loop?
E: I don't know very much what they have been planning, but I suppose it will be more of a situational image, there will be no sense of the environment or the normal sense you would have on a normal ship bridge, not in the near future. It will most likely be a view of the situation, where the ship is and how the systems are running.
P: So the biggest challenge in this would be the data stream?
E: Yes, I would say so.
P: How can you make a system challenge an operator to keep him in the loop?
E: I'd say that a dead man's switch is not a good idea. We will need to make it engaging somehow. There will probably be several ships that the operator will be following, that is one thing that the operator has to deal with,

many places to take care of at the same time. But still, most of the time it will most likely not be much going on, so there needs to be a routine that you would check some things.
P: Like a routine check you do on each ship?
E: Yes, but it is a difficult question because I think boredom will be a big question there.
P: With good data streams and cameras to go through, it could make you stimulated?
E: That would be very good, but I think that data streams is a big problem. Especially when you are at sea you only have satellite connection. The bandwidth is just not enough for high quality video. If we are working in the archipelago or near the coastline, we can stream very high data.
P: Have you explored the idea with 3d-generated images, that just represent the environment the ships are in?
E: There have been talk about that, but the focus is more on getting the data flowing, so we can provide actual video-feed. There have not been too much talk about 3D generated environments.
P: Is there more of a waiting game, for better data streams or can you work around it?
E: It is kind of a two way thing, the service providers know that a lot of more bandwidth is need and are working on it. But there might be a long time before we have a very good coverage. but on the other hand, if you are in the middle of the ocean, there is not a lot of things to stream.
P: In your opinion, what is the most crucial information that needs to be available for the operators at shore?
E: I think the most important thing to know is that the ship is doing what it is supposed to be doing. Some kind of status information, that everything is working fine. Automation and other ship system, the engines are running as they are supposed to and so forth.
P: What are the pros and cons of being on a shore control centre versus being onboard a ship?
E: The clear pro would be that you would not have to do the long crossings and could get home at night and you would not need to work at storms or environments like that. The safety issue is here also, ships still aren’t as safe as they should be, I believe. From the occupational safety side, it would be safer to work in a remote control centre. But the cons then, of course one issue is that you lose the sense of the ship. You don’t know it that well anymore and don’t feel it that way, so if you are remote controlling there might be some difference. The other thing is that how the professionals feel about this, do they feel that they can do their work there, that is a question also.
P: How important do you think it is to have a human as part of the chain of automation?
E: I think this is also a matter of continuous development, I think in the first 10-20 years it will be absolutely crucial to have the human in the loop, because we don’t know the technology that well yet. But after that, who knows, maybe it is completely unnecessary.
P: The way things are going, do you think that we can make the ships fully autonomous, without human interaction?
E: Yes, if we are looking at a very long time, the system getting more and more autonomous. At some point, the human input will be that we put the cargo in and take it out, but that is a very long time.
P: Do you see any problems when humans get less and less in the loop?
E: That’s a very big problem, the degrading of skills. If you are just looking at a thing on a computer screen that works perfectly for 10 years and there is a problem, you have no idea what to do.
P: So my question would be, do you think that, even if you don’t need to, just keeping a human in the loop for those kind of issues?
E: In the long run, I think the systems can be made so robust that no human interaction is needed, but that is a long time from now.
P: Have you worked with making a user-centered design?
E: No, not really.
P: Any ideas on how to manage over and under-trust?
E: No idea I have to say.
P: When working in the AAWA. How much have you looked into existing bridge routines when designing the SCC?
E: Not as much as we should have probably, but we had some discussions with operators of some quite small ships and small ferries. There is some discussion, but not very much detailed information from that.
P: Can you explain any of the user interface or is it only concepts so far?
E: I think it is so much on a concept level so I cannot answer that.

J: In the MUNIN project, they have talked about one operator per 6 ships, in AAWA concerning this, what are your thoughts about this?
E: This is my personal view, but I think 6 ships is absolute maximum. I would say 4 or 5 ships would seem to me that one person would be capable of.
J: In MUNIN, they also have a Situation Room, have you thought of that in AAWA also?
E: One concept in the AAWA is exactly like that, so it would be a remote bridge. But I believe they are not pursuing that so much. A more virtual command centre where you don't even try to mimic a ship bridge, you just provide the information the operator needs and try to optimise it.
J: How do you see the competency and the training of the operators?
E: That is a good question, I think it is quite generally accepted that you still need to have real experience at sea before being able to be a remote operator. But still the operation on shore would be so different, that it would require a completely different education.
P: Maybe in the beginning it would be courses that you had to take for the remote operation?
E: Probably so.
P: You don't think they could make a system so easy that experience at sea would be enough?
E: I think that is the goal, but I think generally the operators will need to understand how the ships operate autonomously. It is also very important in this period of time where we have autonomous ships and conventional ships at the same time, if they all were autonomous it would be very easy in a sense.
P: So the operators will have to come from both worlds, because they have to interact with people that have no knowledge of autonomous ships?
E: Yes and it will be a long transition from manned to unmanned.
J: How about the idea of fewer crew onboard instead of fully unmanned?
E: The first thing that comes to mind is the regulation. How much manning there has to be, I don't think that will change very quickly. I see that as a possible way of doing it. But I don't know if it is a needed step in between, I would pursue for completely unmanned right away, because you would save so much in constructing the ship and not think about accommodation. Tests will be carried out on manned ships and making the crew smaller and smaller, but you would not build a new ship like this, you would build an unmanned vessel right away.

Appendix 4, Interview Christopher Anderberg, Chalmers

P= Peter Barthelsson
J= Jacob Sagefjord
C= Christopher Anderberg

J: Vad jobbar du med just nu och vad har du jobbat med tidigare?
C: Jag är Sjökapten och har jobbat på havet i 8 år i vanlig handelssjöfart och även off-shore, jobbat med DP-system en hel del, anledningen till att jag har hamnat här. Min primära uppgift här på Chalmers är att jobba med utbildning av DP-operatörer och jobbar med lite annan undervisning och projekt på sidan.
P: Vad är bra och dåligt generellt med de automatiserade systemen du har jobbat med?
C: Jag tillhör den kategorin som inte använder mig så mycket av automatiken, föredrar att använda med egen känsla av vad som händer runt omkring. På en nivå är man ändå en del av automatiken och tekniken när man använder den. Sen kan man dra den till en viss längd, sen kan man dra den längre ibland men jag känner att jag hellre har en manuell kontroll. Det finns alltid det med ju mer automatiserat det är, desto mer frånvarande blir den som opererar systemet. Det är väl det som är utmaningen idag när vi går emot mer teknikutveckling och automatiserade system, var kommer vi som operatörer in i det här. Hur kan vi skapa system som ändå kräver aktivitet från operatörens sida att förstå vad som händer men ändå systemet utför det som önskas göra. I den bästa av världar finns en interaktivitet mot det automatiserade systemet där operatören är delaktig men inte utför inte alla kommandon som man gör idag då.
P: Vilka är dina tankar om Situational Awareness när man jobbar med ett automatiserat system?
C: När tekniken väl fungerar, så är det väl väldigt bra. Men det finns vissa som hävdar att vi måste backa bandet, att vi tappar vår Situational Awareness, vad som händer runt omkring ju mer vi automatiserar systemet. Som sjökaptensutbildningen är styrd av ett regelverk som är byggt på ett ganska konservativt traditionell syn. Sjöfartsyrket är mycket erfarenhetsbaserad inlärning och hur lägger man upp den när automatiken blir som den blir, den utvecklas snabbare än vad vi hinner skapa förutsättningar i form av utbildning osv.
P: Tror du man kan få med bitarna från sjöfartens erfarenheter till de automatiska systemen?
C: Jag tror vi är på väg, men så länge STCW ser ut som det gör, så är vi inte där än och då kan en mismatch mellan vad tekniken syftar på och vad vi levererar på utbildningen. Då kan den här erfarenhetsutbildade träningen minska det gapet, men det kan ta lite tid. Men jag tror att ofta kan utvecklarna vara lite väl snabba med sina nya funktioner, utan att förstå förutsättningarna för de som opererar dem. Det finns ju även nivåer av kunskaper när det kommer till nivåer av utbildning. Till hur vi utbildar här skiljer sig kanske från hur man utbildar i Asien, europa i övrigt, USA till exempel. Det finns en annan effekt där också, en aspekt av kultur, att ifrågasätta, vi skandinaver är vanliga med att ifrågasätta men det finns kulturer som inte ifrågasätter.
P: När du kör automatiska system, hur väl är du i loopen?
C: Man är med i loopen när man själv ger sig förutsättningarna för att sätta upp i operationen. Då är man huvudsakligen i loopen, men när man väl är i operation, då kliver du nog sakta ut. Men det beror ju på dig som individ. Ju mindre du interagerar med systemen, desto mer utanför loopen är du. Det har visat sig i olika incidenter och olyckor att när det har hänt saker med automatiserade system och tack vare att individen har varit utanför loopen, så har det varit svårt att hantera systemen och situationen.
P: Hur ser du att man kan utmana en operatör för att hålla dem i loopen?
C: En väldigt stor fråga, men det finns vissa aspekter man kan göra på kort sikt och vissa aspekter man kan göra på lång sikt. Men på kort sikt tänker jag att man måste på något sätt diskutera ombord med en typ av övningar, hur systemen är uppbyggda och hur de fungerar. Man testar olika scenarion för att gemensamt förstå vad man kan göra och inte göra. I en DP operation, tex dykning klass 3, att du behöver trycka på knappar för att du ska förstå systemet, det är inte den vägen vi ska gå, då sätter man en risk i saker, tänk om man trycker på fel knapp i ett känsligt läge.
P: Vad är den viktigaste informationen som operatören bör ha tillgång till hela tiden, på tex MUNINS 6 skärmar?
C: Primärt tror jag det handlar om anti-collision och navigation, i ett bryggperspektiv. Förhindra att fartyget kör på grund, i form av elektroniskt sjökort. Då koppla detta till anti-collision så att man inte kolliderar med andra fartyg. Jag tror väl att sådana här fartyg kommer att kräva att Traffic Controls ger fartygen egna rutter eller korridorer att köra, tex tvärs över en ocean. Det här för att då koordineras med andra fartyg. Så länge fartyget håller sig i sin korridor, så är det okej. Det tror jag är väldigt viktigt. Sen får man lägga till små features som en

watch circle runt fartyget. Om man passerar något så får man en varning och det finns olika sådana gränser. Sen skulle jag även vilja se visuellt, någon typ av kamera så att man kan se vad som händer på plats. Så att man kan göra en bedömning av om vädret stämmer med prognosen eller att se en sån sak som sikt.
P: Hade du varit nöjd med stillbilder som kan komma var 10 sekund?
C: Fördelaktigt hade ju varit video, men det är ju en datakapacitet fråga. Stillbilder hade funkat till viss del.
P: Ser du några fördelar med stillbilder jämfört med video?
C: Det är nog bara nackdelar, för att få en uppfattning om saker och ting behöver man kanske inte kolla på en video hela tiden över en ocean passage. Men det kan finnas aspekter som gör att det kan behövas i vissa lägen men stillbilder är till viss del lika bra, om man har flera kameror som jobbar samtidigt. Om de sitter i tre vinklar förut, så kan man skapa en gemensam ganska stor bild. Då kan stillbilder vara bättre. Radarapparaterna, minst 2 st, måste nog alltid vara livebild, samma med ECDIS. Man får se det lite i perspektiv vad som finns på havet i övrigt, finns det andra fartyg som inte kör med samma system, där det finns operatörer som kör båten så vet man inte riktigt vad de hittar på. De kanske inte är en del av detta konceptet men i framtida ocean passager kanske det styrs av just en Traffic Control Centre som gör en korridor till fartyg. DÅ vet man att här ska det inte finnas båtar i min korridor hela vägen från england till USA. Men när det finns båtar, tex bara fiskebåtar, ensamseglare, så måste jag ha en live-feed.
P: Generellt för- och nackdelar att vara ombord på ett fartyg eller vara i land och styra ett fartyg?
C: Fördelen är ju att du är där, du kan hantera ett problem om det händer någonting på plats. Du följer med vad som sker. Komplexiteten med maskin, kommer det larm, sådana saker. Små grejor, en enkel sak som att man kan känna på temperaturen på vissa saker. Om det börjar brinna någonstans, detektorn kanske upptäcker det för sent, men en maskinist som går omkring hade kanske sett det eller luktat till sig det tidigare. Något som enkelt kan hända är ett hydrauloljeläckage på en styrmaskin, vad gör man då?
P: Ser du några fördelar med att stå på land?
C: Jo, det är klart, en ocean passage är ganska meningslös. Interaktiviteten på nautiker-nivå är väldigt låg. En fördel är att man inte är ombord, man kan sitta i land och köra, man kommer hem på kvällarna.
P: Om man har en storm kan det vara bra att vara där och känna, men är man där i en vecka så kanske man blir lite avtrubbad?
C: Till viss del kanske, men det är bara att gilla läget. Man måste ju ändå kunna reda ut en storm och vara så pass medveten och fräsch i huvudet. Men det är visst skönt att slippa vara ute i dåligt väder.
P: Jag tänker mer på oss som människor om man faktiskt är helt pigg och fräsch.
C: Det är klart det påverkar, men det är nog bättre ändå att vara där. En storm i en vecka, då händer det garanterat något med båten.
J: När ni kör simulator med elever, så har ni en ECDIS-skärm med alla båtar. Ni kan ju ändra kurs och fart på båtarna som inte styrs av elever. När ni styr dessa fartyg, har ni bra kontroll på alla dessa båtar då? Känner du dig in the loop?
C: Nej, det kan man inte ha alltid. Vi kör ganska snabba scenarion, så det händer saker hela tiden. Kan vara mycket trafik och tight navigering. För att få mer kontroll, så hade vi kunnat dela upp båtar på lärarna, om man bara har två båtar så hade man kunnat manövrera dem bra.
P: Är det två båtar som du känner att du hade kunnat ha koll på då?
C: Två till tre båtar. Jag tänker mer komplexiteten på trafiken då. Ju mindre komplexiteten på trafiksituationen, desto fler båtar. Utgår man ifrån ganska tight navigering och tight anti-collision, så är det två båtar.
J: När ni kör i simulatorn kör ni ju i samma område, ECDIS-skärmen täcker hela detta området. Men hade det gått lika bra att köra två båtar i olika områden, där du får byta skärmar beroende på vilken båt du monitorerar?
C: Jag kan kanske jobba med flera båtar samtidigt, men jag kan inte ha hur många skärmar som helst att titta på, men jag kan ha skärmar som ger situation för alla båtar, då kan jag hantera fler båtar samtidigt. Trycker jag på en båt, så jag får upp hela plotten för den båten på mina skärmar, då kan jag jobba mer aktivt med den båten. Blir det mer komplext på en båt, då kan jag inte titta på de andra båtarna. Komplexiteten avgör hur pass aktiv man kan vara, ju mer komplexitet, desto mer information behöver man.
P: Hur viktigt är det att ha kvar en människa i kedjan av automation?
C: Så länge fartyg är som dem är, komplexa enheter, det händer grejer. Det kräver en pinpointad insats ibland. Är fartygen byggda som de är idag, så behövs det en människa i loopen. Det händer saker till sjöss som är svåra att föreställa sig, men har en förmåga att inträffa.

J: User-centered systems kommer mer och mer, vad tänker du om det, att användaren ska vara del av utvecklingen?
C: Det är bra på pappret, men funkar sådär i verkligheten. Det har varit diskussion jättelänge, men så länge regelverken och klassningen av fartyg ser ut som den gör idag, så är det väldigt komplext att få in användar perspektiven. Det kommer nya features som utvecklas. Det har man varit med om flera gånger att systemen har kommit ombord och så får man en timmes crashcourse innan teknikern ska flyga därifrån. Sen är det good to go, så står systemet bara där för att man inte har fått informationen som behövs för att kunna använda systemen.
P: Så man skulle egentligen utveckla relationen med sjöfolk och folk som utvecklar systemen?
C: Fortfarande en loop som inte fungerar riktigt. Samtidigt frågar man sig varför de gör så här med ett system som har fungerat så bra tidigare. Bara för att man utvecklar nya aspekter, tex det komplexa ECDIS-systemet, hur mycket av alla funktionaliteter använder man. Studenterna här kanske använder 20%. I rutt planeringen använder man mer, men i monitorerings läget cirka 20%.
P: Borde man använda ECDIS-systemet mer?
C: Behöver man göra det, det är frågan egentligen. Tänker man det perspektivet, jag använder 20% i den aktiva navigeringen, behöver jag kunna resten? Jag behöver ha en förståelse av att det finns, men i en tight situation där jag behöver information fort, så har jag inte behov av att kunna använda allt det där.
P: Tror du att det hade kunnat funka bättre om man kopplar ihop sjöfolk och utvecklare?
C: Det tror jag är jätteviktigt. I ett projektet jag var engagerad i, kom operatören väldigt tidigt in. Men vi kände ändå att från utvecklarnas sida att vi inte vill ha alla funktionerna, eller alla knapparna. Det blir bara omständigt, vi vill ha informationen väl presenterat och det bygger nog lite grann på att sjöfolk är ganska konservativa. Man lär sitt sätt att jobba och man behåller det sättet.
P: Vad krävs för de som utvecklar för att du ska lita på deras system?
C: Jag märkte att i slutet av mina 8 år att jag använde mindre teknik ju mer erfaren jag blev. Litade mer på min erfarenhet, känslan av saker och ting. Man får en uppfattning av saker, som om man går i Singapore Strait så vet man att dessa båtar kommer göra si och dessa båtar kommer göra så, så man behöver inte längre plotta alla båtar på ARPA för att förstå vad båtarna kommer göra.
J: Tänker lite på in the loop när du är lärare på en simulatorkörning. För du kan ju ändra kurs på båtar som eleverna inte kör. Om du nu skulle bli inslängd i en situation där du inte hade någon förberedelse. Skulle du känna dig in the loop, hade du klarat dig med 2 båtar?
C: Det hade varit mer komplext, då hade jag behövt ett par minuter bara för att förstå. Man kan ju titta på vissa saker inom en 30 sekunder - 1 minut för att se om det är någon nära fara eller vad statusen är på det fartyget. Men för att förstå en hel trafikbild, då behöver man betydligt mer tid, men 30 sekunder i det korta perspektivet. Man kan ju ändra farten för att få mer tid.
P: MUNIN har ju en idé om Situations Rum med ett brygg team, som kan ta över larm. Tror du att det är möjligbart?
C: Det måste gå, man kan inte ha en skärm för varje båt, eller ett system för varje båt. Man kanske jobbar med 10 båtar samtidigt och när det händer något får man ta in fler folk på något sätt.
J: Det blir ju nästan samma exempel då, man får en båt och hoppar in den situationen direkt. Man vet hur situationen är, det har larmat om de två båtarna som ligger där framme, men du känner inte till din generella position men du har situationen runt dig och ecdis-skärmarna osv. Men du vet inte exakt var på jorden du är.
C: Jag tror det är en intressant synpunkt på det att de som opererar båtarna opererar båtar i samma område hela tiden, så att du bygger SA i det här området, då bygger man erfarenhet vilket är jätteviktigt. Man får en helt annan förståelse.
J: Om man ska ta över ett fartyg och fjärrstyra, tror du att det är viktigt vart du är i världen?
C: Det beror på, mitt i Atlanten så spelar det inte så stor roll, medans mitt i Engelska Kanalen så kan det vara viktigt.
J: Tänker du att det kan vara mycket stor skillnad på Engelska Kanalen och Stora Bält som ändå kanske har samma utrymme på vissa sträckor.
C: Både Engelska Kanalen och Stora Bält är komplexa områden, nu har inte Engelska Kanalen den anti-navigatoriska risken eftersom det inte är lika tight. Kör man ett fartyg med 7-8 meters djupgående är Stora Bält genast mer tricky än vad Engelska Kanalen är.
P: Vi har funderat lite på det här om man ska ha 6 båtar eller om man ska ha ett område där du kör alla båtar.

C: Jag tror på området, att kunna området är jätteviktigt. Samtidigt kräver det en överlämning, där får man utveckla procedurer för överlämning. Men har man grundförståelse för ett område så kan man förutse trafiksituationen också.
P: Om man har ett Situation Room och man har en operatör som har en båt som larmar, så kommer ett brygg team som tar över båten. Den primära operatören som har förebyggande kunskap om båtens situation, ska han gå in och vara med i teamet?
C: Det tror jag nästan är en förutsättning för att få en uppfattning om situationen, han kanske inte behöver vara med hela tiden men han måste få ett läge att briefa teamet. Det beror på vilken grad han har följt fartyget, att briefa situationsrummet och sedan släppa det kan vara tillräckligt. Han behöver inte nödvändigtvis vara med
J: Som en skype eller annan videolänk?
C: Ja, så att han ger dem samma bild som han ser. Jag tror väl att operatörer kommer sitta i team med kanske 20 personer och dessa 20 operatörer har teamleaders som då kan vara sjökaptener och är mer ansvariga.
J: När ni kollar studenter som har körningar i simulatorn, vad är de vanligaste misstagen i human-machine interaction?
C: De vanligaste misstagen är nog att information är där men man tittar på fel saker. Man tittar på annat och inte informationen som finns på tillgängliga. I en körning vi har så kommer ett fartyg från babord som ofta upptäcks väldigt sent, för att man har så mycket annat.
J: Skulle enbart information från ECDIS och RADAR vara tillräckliga om informationen har validerats av ASM?
C: Det tror jag inte är några problem, att man kan utveckla vad man presenterar på en radar eller ecdis-skärm, kanske räcker med en skärm med integrerat radar och ecdis. Man kan ge olika sensorer input så man kan se väldigt tydligt vad statusen är på fartyg. Man måste integrera lösningar som finns idag, till en och samma skärm.
J: Vilken information är mest viktig i Anti-Collision-Situationer?
C: Framförallt avstånd och tid, så att säga.
J: Din fartygs rörelser relativt andra fartygs rörelser?
C: Ja, hur vi ser ut liksom. Sen kan man gestalta det på olika sätt, antingen digitalt med siffror eller med någon form av annan vektor-baserat system.
P: Kan tänkas en 3d-genererad bild som visar för att ge en situational awareness.
C: 3d kan ju vara något, det kan vara så att tekniken kommer så pass långt att den bilden man ser kan gestaltas i storlek på fartyg.
J: Tror du att olika operatörer vill ha olika inställningar för sina setups?
C: Det måste finnas en performance standard i grunden, sen kan man göra egna inställningar.
J; Vilken information är viktigast i Anti-Grounding-Situationer?
C: Det handlar om fartygets relation till vad som finns runt omkring. Genom bild av vad som finns runt omkring, det kan man definiera på olika sätt. Säg att du sätter djupkurvor som är kopplade till ett safety-depth, belyser dem här områdena som är navigerbara just för dig. Då ser man snabbt vad som är navigerbara vatten.
P: Några spontana tankar du har haft under tiden?
C: Det är ett intressant område, som kommer debatteras och forskas på i flera år. Tror det är viktigt att de som produktutvecklar, tillverkarna verkar gå stora steg, men jag hoppas att de har operatör inkoppling, vilket är avgörande för att det här ska kunna fungera. Inte skapa system som blir omöjliga att hantera, eller för mycket information.
P: Vi har diskuterat lite om skiften och att det ska vara överlappande skift så att när du tar över en båt så har den crosscheckande operatören suttit där ett tag. Så det går alltid att fråga honom om vad den föregående operatören har gjort.
C: I DP-systemet pratas det väldigt mycket om redundans och här har du då redundans.

Appendix 5, Interview Anders Johannesson, VTS Göteborg

P= Peter Barthelsson
J= Jacob Sagefjord
A= Ander Johannesson

P: Vad gör du nu och vad har du gjort tidigare?
A: Jag började till sjöss efter gymnasiet då var jag 19 år, och så jobbade jag i manskaps befattningar under några års tid, och sedan så började jag läsa på sjöbefälsskolan och blev färdig 84' och jag började segla som styrman 89-90' sedan började jag i sjöfartsverket 95' och de första 10 åren körde jag lotsbåt och satt i lotsutkik, det man idag kallar för vts. De sista 12 åren har jag jobbat här i vts göteborg, och nu jobbar jag halvtid som vts operatör och halvtid som chefsinstruktör för blivande vts-operatörer..
P: Vad brukar vts-operatörer ha för bakgrund?
A: Den vanligaste bakgrunden är att man har (ska) läst sjökaptens-examen. Det vanligaste är att man varit ute ett par år till sjöss och tröttnat och sedan sökt ett jobb i land. Om man varit låt säga 10 år till sjöss är det vanligare att bli lots istället.
P:Så alla egentligen har bakgrunden?
A: Det finns även de som varit väldigt länge i sjöfartsverket som blivit kvar, som jobbade på lotsutkikarnas tid, och på den tiden så gick jobben ofta i arv, man hade inte sjökaptensexamen utan kom in på annat sätt och har alltså fortfarande kvar sin tjänst
P: Samarbetar ni något med lotsarna?
A: Inte jättemycket, men en del
P:När ni jobbar, vad gör ni för att få en så hög SA som möjligt?
A:När någonting händer, ju mer systemet klarar på egen hand, desto bättre är det, eftersom det är lätt att människan själv missar saker, man kan tex vända sig om och prata med någon, eller hämta en kopp kaffe, och så går det en minut. Grunden är ju att vi sitter och övervakar de här skärmarna och tittar på dem och lyssnar på radio trafiken, och där bygger vi vår SA. Men VTS systemet skall hjälpa till så mycket som möjligt så vi inte missar någonting.
P: Så du känner egentligen att en högre nivå av automation är bättre?
A: Oja
P: Det blir aldrig så att i vissa delar av systemet så blir det för mycket, alltså att man kanske sitter där och blir lite frånvarande.
A:Nej, inte på det sättet, men vad däremot kan bli och det vet ni säkert själva också, att man har ett system som ska till exempel larma för om ett fartyg är på väg att lämna farleden, och det är klart att det är ju fler och fler fritidsbåtar som AIS idag, så det där larmet kommer ju gå oftare och oftare, så så sett kan det ju bli för mycket larm så man till slut inte reagerar.
P: Skulle ni vilja separera de då?
A: Det kan man faktiskt göra, men då är det ju så att då ser man ju faktiskt inte dem heller.
Det är klart, talar man om för ett fartyg att det finns ingenting i vägen för dig, men ändå det kan ju vara nånting där som vi inte har sett.
P:Tycker du att ert system ger tillräckligt hög nivå av SA
A: Den får gärna ge mer
J: Vad tänker du att du skulle vilja ha för utrustning då, kamera?
A: Naej, det systemet vi har bygger ju på radar och ais, men det man kanske skulle vilja är att systemet larmar för mer saker, säg att ett fartyg då kanske rör sig med 12 knop framåt, och så saktar det ned, det skulle det gärna kunna larma för. Allt som avviker från den vanliga trafikbilden.
P: Så det larmar det inte för alltså?
A: Nej, det är möjligt att det går att ställa in.
P: Vi diskuterar just nu mycket om olyckor som orsakas av att folk får för hög tilltro till automationen som vi har, att man litar för mycket på system, så vi försöker fylla i det här gapet. Så vi undersöker om vi kan använda oss av era erfarenheter för att fylla i det.
P: Vad är din största oro angående SA, förutom nedsaktande som vi nämnde innan?

A: Det finns ju vissa situationer som vi vet att det kan vara en risk med, tex när ett fartyg skall ta lots, då vet vi ju att den här båten kommer att göra en tvär gir, för att göra lä för den här lotsbåten, och vi vet ju också det att i den stunden så är lotsen fokuserad på att komma ombord på fartyget, och han som kör lotsbåten är fokuserad på att ta sig till sidan, och kaptenen är intresserad av att ta ombord sin lots, och i det ögonblicket så släpper de sin egen SA, eller “domain awareness”. Om det tex kommer ett snabbt roro-fartyg akterifrån och de plötsligt svänger.. Så sådana situationer är vi medvetna om och håller närmare översikt över.
P : Känner du att ni har en bättre översikt än båtarna själva i en sådan situation?
A : Ja det tycker jag, vi får ju som ett sorts helikopterperspektiv.
P: Finns det någon annan situation där ni känner att ni kan missa någonting, eller att de på båtarna har bättre koll än vad ni har?
A: Ja, det tycker jag, om vi säger att vi har 2 fartyg som är på väg och möts, och så kommer det ett tredje fartyg som vill köra om. Ofta så har de då bättre koll på om de hinner eller inte, våran uppgift då är att informera och kolla så de inte missat den mötande båten. Men om de säger då klart och tydligt att de vet det, så har de en bättre koll på om de hinner eller inte än vad vi har.
En annan situation är om vi tittar tex i Skandiahamnen och vi har en containerbåt som skall gå, och så kommer det en färja inifrån, lotsen ombord vet bergsäkert om han kommer hinna att gå före färjan, medans det för oss är svårt att bedöma, då vi inte riktigt vet situation ombord på båten. Vår uppgift är bara att tala om att färjan är påväg in så att de inte missar det.
P: Så just sådana situationer där ni skall göra en bedömning i vad ni hinner och vad ni kan och inte kan?
A: ja precis, kommer det ta 3 minuter eller 6 minuter eller 4 minuter?.. Där vill jag påstå att de har en bättre möjlighet att bedöma ombord
P: Finns det något man kan göra från eran sida för att få en bättre koll på detta?
A: Nej, det tror jag inte, det är så vi arbetar på svenska VTS, vi är ju en informations service. VI försöker att förse befälet eller lotse med en typ av domain awareness, det här och det här håller på att hända, sedan får de själva fatta beslut om vad som skall göras
P: Vi har något vi kallar för att man skall vara “in the loop” alltså när ni jobbar med ert system, utmanar det operatören för att se till att man är kvar i loopen mellan systemet och människan?
A: Nej, inte som jag upplever det, men du får gärna ställa frågan igen efter att vi varit där uppe och kollat på det.
P: Det jag menar är det att, tex på en båt har vi ett larm man skall trycka på var 12te minut..
A: Inte på det sättet, man kan säkert fixa det om man skulle vilja..
P: det finns inget som gör att du måste kolla på visa menyer eller bilder osv?
A: Nej
P: Vilken är det viktigaste informationen som skall finna tillgänglig när ni övervakar fartyg i hamnen?
A: Vi har ju vektorer, ungefär samma som ARPA systemen, det som kommer till nu snart, är STM och Mona Lisa, att man kommer kunna se fartygens rutter.
P: Så ni skulle vilja ha som en ECDIS där ni kan se vilken track de har lagt?
A: Ja det är lite så man tänker sig, egentligen skulle man väl ha typ en ecdis med rutterna och en utan, alternativt att man lägger in Mona Lisa klienten i ecdis så de funktionerna ligger där också. Det hade ju varit fint för oss att ha också
P: Då ser ni ju om de reviderar också..
A: Ja, fast, det är jag inte säker på i vårt fall eftersom det är så pass trånga farleder så det är frågan om det blir så exakt. Men om vi nu tar Tärnvind och stena Jutlandica, om en dator från början kan räkna ut att de kommer att komma väldigt nära varandra och att de kommer vid en viss tidpunkt vara si eller så nära, och att det larmet kommer tidigt. Det kan ju en vanlig ecdis göra, men den kan ju inte göra det i törnar eller böjar och svängar, men låg rutterna ute så skulle man ungefärligen kunna komma med predictions.
P: Vad tror du är för och nackdelar med att sitta på land och köra en båt, du sa att en fördel var att man får ett bättre fågelperspektiv, men ser du några andra fördelar eller nackdelar?
A: När jag pratar VTS i olika sammanhang så har jag en bild som jag visar ibland, att man får tänka sig att vi alla vill ha så säkra hamnanlöp som möjligt och en bra början är ju att man har en hamn, en utprickning, det kommer ombord en lots, det blir ju delar i att göra det säkrare och säkrare, och har du då en VTS som övervakar och kan se och kommer med en second opinion att du tex håller på att lämnar farleden, eller att du har ett möte som kommer att bli på ett trångt ställe, då blir det ju säkrare.

Jag tänkte också på det du sa om var man har bäst överblick, jag håller ju som sagt kurser i det här, och då är det en av lotsarna som brukar vara med och hjälpa till, han brukar i sitt föredrag visa olika bilder, och han visar dels hur det ser ut från VTS och från ett fartyg som har bra ecdis och bra utrustning, och redan där blir det lite sämre, för vi har ju radar som är utspridda, och sen visar han fartyg som är ännu sämre och kanske inte har ecdis alls och där kommer man ju ännu längre ned.

P: Skulle ni känna att det var bra att få tillgång till fartygs radarbild?

A: Nej.. Visst kan man alltid säga ja tack, men om man ska svara realistiskt, vad det tekniskt skulle lösa och kosta och vad det skulle tillföra, så tror jag inte det skulle tillföra jättemycket

P: Vi tänker väl, som man har pratat nu, så är det så man kommer köra de autonoma fartygen, man kommer att se dess radarbild och kameror och så ifrån en landstation, och just en radarbild är inte så mycket data, så det skulle bli relativt billigt.

A: Nej. jag tror inte det

J: Jag kan ta det också då, om VHF kommunikationen, om man har obemannat fartyg som ni behöver ta i kontakt med, hur mycket fördröjning skulle ni kunna acceptera.

A: Jag vet inte. Men när vi kommer till skärgårdsnavigering så är det ganska kort tid, kanske 20 sekunder?

P: Det är ju ganska lång tid ändå…

A: Vi säger 10 då..

P: Nu påverkade jag dig..

A: Det är klart det är svårt, för att det blir svårt att kommunicera, om det tar 20 sekunder för dig att svara och sedan 20 sekunder till för mig att höra dig, det blir väldigt svårt att få en vettig kommunikation, men om jag med 20 sekunders försprång får säga det jag vill ha sagt så hinner jag nog informera dig om vad jag vill ha sagt, innan det smäller så att säga.

P: Så länge det inte uppstår en stressad situation..

A: Ja

P: Om vi kollar igen på eran bakgrund, de flesta av er hade en bakgrund från handelsflottan, om vi kollar på våra bryggrutiner, är det något ni använder er av när ni jobbar på VTS?

A: Nej. jag tror nog inte vi har så mycket gemensamt egentligen..

P: Checklistor till exempel?

A: Jo sånt kan vi ha, men annars tror jag inte det, det är skillnad på när du själv framför din båt, för då lever du ditt liv, medans vi har ett helt område att ta till hänsyn på på ett annat sätt

Det är liksom inte meningen att vi som sitter i VTS skall vara någon sorts co-pilot, utan han är där för att förmedla information och bygga upp en domain awareness hos fartygen.

P: Det vi kollar på här är något man under våra kurser kallat för challange and response, att man kollar vad den som sitter bredvid gör, är det något nu applicerar

A: Nej utan vi sitter ju alltid ensamma. Även om det finns VTS där man har flera olika VTS områden så varje operatör ansvarar ju för sitt område, i alla fall inget formellt samarbete.

P: Så det är alltid en person som sitter själv och övervakar här i göteborg?

A: Ja.. aldrig.. Det är väl.. När ostindiefararen Götheborg kom in och i sådana extrema förhållanden så är det ju bra att vara två.

P: Så ni kan få hjälp?

A: Ja, men då får det vara planerat länge i förväg, det är inte bara så att vi kan ringa efter någon som har jour, eller att någon kommer in hoppandes.

J: Hur långa skift har ni?

A: 6 timmar

J: Och när ni tar över, har ni något överlappande, eller någon speciell avlösning?

A: VI har en avlösningstid som ligger i schemat, den är generöst tilltagen, den är 30 minuter, men det är inte för att det tar 30 minuter utan det var en förhandlingsfråga, man skulle göra schemat och det skulle gå ihop. Då blev det så. Innan när vi hade det gamla avtalet så var det 17 minuter. Det tar inte så lång tid. Det är oftast gjort på fem minuter.

J: Men du känner inte att det kan behövas då, om vi säger att man kommer in 30 minuter, och sen, om i det första alternativet har tagit 10 minuter och sedan hade ni gått. Men sedan har det gått 20 minuter till och så är det en situation som uppstår som man inte riktigt förstår för att man inte riktigt vart där genom hela situationen..

A: Jo absolut kan det vara så, men jag vill påstå att det är så teoretiskt sett, men praktiskt sett så blir det väldigt sällan på det viset.
Det är inte så att du sitter kvar där och så har han gått och så tänker du men vad är nu det här, eller vad är det som händer nu, det kan det ju teoretiskt vara men det är väldigt ovanligt
P: Jag kan tänka mig att det uppstår en exceptionell situation..?
A: Ja då stannar man ju, om vi tex säger att ett fartyg gått på grund precis vid avbytet. Visst stannar man ju.
J Hur arbetar operatören aktivt med sina fartyg?
A: Det som vi gör, det är ju att dels så finns det ju rapporteringspunkter där fartygen skall rapportera till oss att de passerar och vart de är påväg då får de information tillbaka om vad som rör sig i området som är relevant för dem. Den andra biten är som du säger just att vi följer dem hela tiden och någon gör något som ser konstigt ut eller är direkt olämpligt, så kan vi komma med extra information tex: Det är fyra fartyg på väg in nu i den här kröken du passerar, eller att man kommer med en fråga, har du tänkt att gå den leden eller har du tänkt att köra om den här båten. Eller har du tänkt att ankra på norra sidan av rivöfjorden eller… att man kan komma med någon extra information som kan vara något där.
P: Finns det någon gräns för hur många fartyg ni klarar av att monitorera samtidigt?
A : Ja, det gör det, men den finns inte klart definierad och den skiljer nog från operatör till operatör. För min egen del.. Jag kan inte säga hur många men det kommer till en gräns när det blir för mycket, och då börjar jag missa sådant som jag borde haft med vid informationen vid rapporteringspunkterna. Jag kan också märka på mig själv att jag blir stressad och jag kan reagera med att jag blir irriterad, det har har blivit för mycket
P: Nu kommer vi lite in på det vi håller på med om autonoma fartyg.. Och utifrån din erfarenhet, om du skulle haft ett fartyg som kommer in och kör autonomt, och fartyget kan ta hand om anti-grounding, anti-collision och alla trafiksituationer själv, men du kan välja dess rutt.. Skulle ni känna att detta skulle kunna vara ett fungerande scenario?
A: Ja det tror jag nog, men jag har svårare att tänka mig att fartyget kommer kunna.. Det är ju en sak ute i oceanen men i en skärgårdsmiljö så har jag svårt att se att den skulle kunna lösa anti-grounding och anti-collision..
P: Men om vi säger att den kan det..
A: Ja. det kan jag nog tänka mig..
J: Jag tänker mig så här att man har drag and drop rutter på eran ecdis skärm så ni direkt manipulerar trafikflödet.
A: Det skulle man nog kunna göra..
P: Så att det är ni som väljer vilken rutt de ska ta in i göteborg
A: Ingenting jag tänkt på men spontant så skulle de nog funka
J: Är det några trafiksituationer som är särskilt svåra att hantera?
A: Det är väl egentligen det som vi var lite inne på förut att dom där på något sätt måste bedöma hur lång tid kommer det här ta, kommer den här båten att hinna göra si eller så
Det är ju svårt. Vi kan ta ett litet exempel som jag har med ibland: Då har vi en kusttanker, jag tror det är vinga safir, som går från cityvarvet, och utifrån kommer stena danica och de har inte riktigt kommit överens om vad de skall göra. Skall danica vända runt och backa in i sitt läge medans vinga safir väntar, eller skall vinga safir köra på så att de möts så, eller skall rent av danica vänta. De som är ombord har antagligen en bra uppfattning om vad de hinner, men om man sitter på VTS så ser man att det här är en situation som kanske kan spetsa till sig. Och då vill man ju vara ute i god tid och informera de här om att nu kommer danica och de kommer att vända, tänker ni vänta eller tänker ni göra något annat, i sådant fall får ni komma överens om detta.
Just det där att bedöma om det är någon risk eller inte, ibland kan det vara någon båt som ska in till skarvikshamnen, som ska vända och backa in, och hur lång tid tar det jämfört med stena jutlandica att köra ifrån masthugget och ut dit.
P: Skulle du säga att från ert perspektiv så skulle ni vilja ha större marginaler om ni körde båtarna?
A: Ja det tror jag. Det är ju också.. Jag har ju inte bråttom, jag ska ju inte ut någonstans, så då vill man ju gärna ta ut marginalerna så mycket som möjligt.
Vi har pratar lite om man skall vara strängare. Det finns ju olika servicegrader på en vts, det finns informations service. Navigations assistans, och trafikorganisation, har man då trafikorganisation då är det ju VTS som styr och ställer med båtarna, vi har ju trafikinformation. Jag behöver bara tala om för dig att tex stena danica går,

men om det var så att jag skulle bestämma att du inte får gå förrän stena danica gått, då skulle man ju ta ut marginalerna mer. Då skulle man ju bara ännu oroligare att något hände
P: Så om du bestämde så skulle det bli mindre effektivt?
A: Ja det tror jag. Nu har ju nästan alla större hamnar den typen av service-grad, och det fungerar ju alldeles utmärkt, men jag tror att det finns en viss risk att man tar ut större marginaler än annars
P: Det visste jag inte att det fanns.. Det är väldigt intressant för oss..
A:När jag föreläser om det här, då säger jag att det enda som är viktigt, det är just det här att det finns olika service grader, informations service - ni får information, och gör vad ni vill med den. Trafikorganisation - då får ni rätta er efter det som VTS säger om det inte är direkt livsfarligt. Navigations Assistans som är i mitten är en annan sak, då hjälper vi er att navigera eller att hålla reda på er position eller tendens, om ni driver si eller så, eller om ni behöver veta om var en ankarplats.. Mer att hjälpa till med navigationen men inte bestämma
P: Vad är den viktigaste informationen i olika situationer, för tex anti-collision, vad vill du har för information då? CPA?
A: Ja visst det är ju lätt att säga CPA, men tiden är nog också väldigt intressant, och platsen
P: Så exakt som möjligt då?
A: Ja.. var och när kommer de här två att krocka om de fortsätter som de gör..
P: Samma fråga fast anti-grounding?
A: där skulle man väl i sådant fall gärna sett att systemet kunde ta in från AIS att båten har 8,5m djupgående och är påväg mot ett område som är 8m djupt så kunde det larma för det, istället för att larma för specifika områden för alla båtar
P: Är det något mer du känner att du spontant tänkt på under intervjun som du vill nämna?
A: Ja, jag har faktiskt varit med i det här MUNIN projektet, och fick testa detta i simulatormiljö. Det var med Reto Weber och Yemao. Rent spontant skulle jag vilja säga att jag tror ju på det här men att det skulle vara över oceanerna och att när man närmar sig land så sker det precis som det gör idag med lotsar och bogserbåtar osv. Jag skulle inte vilja se obemannade fartyg med kanske 25000 ton råolja komma in i skärgården..
J: Ja det blir ju stegvis..
P: Det kommer ta lång tid, men det är ju en färja nu i norge som skall åka över en fjord..2018-19
A: Jo.. men jag har ju funderat över nyttan över det här arbetet.. Om det bara är besättningen, det är ju inte en så jättestor besparing om man jämför med bunker
J: Det är ju om en person kan kontrollera flera fartyg så…
A: ja det är klart..
J: så tänker man att man kanske kan ta rå-laster och lägga dem i strömmar och låta dem driva..
P: Ja de tänker ju även slow-steama väldigt mycket.. Men det är ju underhåll också, vi pratade lite med wallenius, och de påstod, om ingenting går fel så kan de köra 35 dagar utan underhåll
P: Fördelar med att tillgång till kamera-feed från båtarna, skulle ni vilja ha det?
A: Ja, det skulle vi ha större användning för än att ha RADAR-bilden, för RADAR-bild det har vi. Det är klart, att se det dem ser, tillför ju någonting. Det kan finnas en risk med det också, för dem kanske inte ser det jag ser i kameran. De kanske är upptagna med något helt annat, de kanske pratar om lastoperationer, man ska inte ta det för givet att om jag ser att en fiskebåt kommer så kanske inte dem är uppmärksamma på det. Men det skulle självklart tillföra, det skulle bli ett nytt perspektiv.
P: Och även se deras rutt då.
A: Ja, mycket av det som finns i STM-projektet skulle jag gärna se i VTS-systemet. Det är väldigt nära förbundet med varandra.
P: När vi gick runt och kollade så pratade vi lite om en grej där i slutet.
A: Det var om lotsbeställningar, de har bäst koll på vad som ska hända, för att velar man för mycket börjar det kosta pengar. Det är ett svårt jobb, eftersom alla har en egen agenda, mäklare vill någonting, de ser sina båtar. Bogserbåt Bolaget ser sitt och lotsar ser till sin bit.
P: Vi pratade lite om att ni jobbade själva och att ingen kollade på er, men när ni satt där så satt ni ändå och samarbetade lite.
A: Det gör vi på ett sätt, men bara för att krångla till det lite mer så lägger jag till två begrepp till. Vi har pratat om Informations-service, Navigations-assistance och Trafik-organisation, organisation var tvingande och information mer rådgivande. Sen skiljer man mer på Port eller River Service och Coastal Service när man pratar om VTS. Det här är en typisk Port Service VTS, som vi är, vi är väldigt tätt knutna till en hamn, båtar ska in och

ut. Sen finns det också Coastal Service som tex Dover Strait där man övervakar en passage mera, man är inte knuten till en hamn. Det jag vill komma till, vi i egenskap av att vara Port Service VTS, vi har mycket med hamnen att göra, vilka kajer som är lediga. Men vi har inget samarbete då med att de tittar på trafikbilden, eller på det som är vårt arbete. Jag kan ju fråga min kollega ändå, men vi har inte det samarbetet, vi är ensamma i själva VTS-tjänsten.
P: Lotsarna, frågar ni om tider då, när tror ni dem vill köra in?
A: Det kan man göra då, också något man är osäker på, de är väldigt kunniga. Så man kan klart vända sig till en lots och fråga. Men det är något som inte är så formaliserat. Ett samarbete vi har med lotsar som är formaliserat är om det blir storm eller stormvarning. Då har vi en lots med i VTS också, då har vi ett direkt bollplank med lotsarna, då kan vi fråga dem om olika saker, som om det är lämpligt att den här båten ligger till ankars eller om den ska göra si eller så. Då kan vi ta nytta av deras expertis, men det är i samband med dåligt väder.
P: Nu sitter ni ändå på samma ställe, VTS, Port Control och Lotsbeställning. Lotsbeställningen har ju väldigt bra koll på tider iallafall.
A: Så kan vi ha ett samarbete, men inte i det som egentligen är att övervaka och informera fartyg om det är lämpligt att mötas, lämpligt att köra om, om det är mycket mötande trafik osv.
P: Om vi fantiserar lite igen och säger att du har så att du kan välja rutter för båtar eller något liknande, skulle ni kunna samarbeta mer då?
A: Det tror jag inte spelar någon större roll faktiskt.
J: Jag tänker när stormlotsen är här. Får ni Pilotcard hit eller är det AIS-data han har tillgänglig?
A: När han är här i egenskap av stormlots, då använder han våra grejor, AIS-information och VTS-systemet. Sen har ju varje lots en handdator eller en form av sånt, vet inte riktigt hur det fungerar.
J: Tänker om han är nöjd med valen han gör, baserad på den information han har från era system?
A: Det får han basera sina svar på, från det som kommer från oss. Vi har inte haft stormlots jätteofta, vi har bara haft det i några få år.
J: Lotsar som kommer ombord direkt på ett fartyg, hur fungerar informationsutbytet mellan er för att de ska få en situational awareness så fort som möjligt?
A: När lotsarna kommer ombord, i Göteborg så finns det en rutin att de ropar på oss för att få en uppdatering om trafikläget, vad som är närmast mig just nu och vad har dem tänkt sig, vart ska dem.
P: Vad brukar ni ge för briefing, utöver det?
A: De vill ha det som är närmast dem. Om lotsen kommer ombord ett par mil söder om Trubaduren, vill han veta vad som rör sig runt Trubaduren och kanske en bit upp. Men ungefär så, han behöver inte veta vad som rör sig i hela området med en gång. Han får det som är närmast och sen kommer han till Rapporteringspunkt 1 och då får han en uppdatering igen.
P: Det är ingen väderinfo då?
A: Det är mer sällan, det är faktiskt väldigt sällan vi pratar väder. Det är om någon frågar oss, vi har vindmätare på några ställen och vi får prognoser från SMHI som är gjorda för Göteborg.
P: Vart är de här båtarna på väg och vart är de på väg?
A: Japp, det är det vanligaste
P: I MUNIN har man pratat om en Situation Room, där ett team får ta över en båt som har larmat ganska fort. Då pratade innan om att ni kan byta operatörer ganska fort om det är optimala förhållanden. Då hade en operatör släppa sina båtar i fall ett larm uppstår till en annan operatör och gå med in i Situationsrummet.
A: Det låter väl tänkbart.