YRKESHÖGSKOLAN NOVIA

Autonomous Shipping in changing the structures

Future implications on Maritime Education and Training

Björn Pundars

Master's thesis

Master of Engineering, Autonomous Maritime Operations

Kalmar, May 2020

EXAMENSARBETE

Författare: Björn Pundars
Utbildning och ort: Master of Engineering, Åbo
Inriktningsalternativ/Fördjupning: Autonomous Maritime Operations
Handledare: Micael Vuorio, NOVIA och Jouni Lappalainen, TRAFICOM

Titel: Autonomous Shipping in changing the structures - Future implications on Maritime Education and Training

---

Datum 20.05.2020 Sidantal 58 Bilagor 3

Abstrakt

Ny teknologi utvecklas och implementeras inom den maritima sektorn. Målsättningen är att ha autonoma (självstyrande) fartyg i framtiden. Detta kommer att påverka bl.a. lagstiftningen, mänskliga faktorer och utbildningen. Min avhandling "Autonomous Shipping is changing the structures" fokuserar på implikationer inom sjöfartsutbildningen. Forskningsresultatet bidrag till det arbete inom självstyrande fartyg vilken pågår hos Transport- och kommunikationsverket (TRAFICOM) och Aboa Mare (NOVIA). Min forskning undersöker hur utvecklingen inom autonom sjöfart inverkar på strukturen och den maritima utbildningen.

Forskningen inom fyra områden undersöks: 1) Lagstiftning och regler, 2) Fjärrstyrning, 3) Mänskliga faktorn och 4) utbildningen. Forskare har konstaterat att ändringar och anpassningar bör göras då vi börjar operera självstyrande fartyg. 16 personer representerande företag, myndigheter och utbildningsorganisationer har intervjuats för dem empiriska delen.

Resultatet visar att forskningen och insamlat material från intervjuerna stöder varandra. Det finns många olösta frågor, inte enbart tekniska. En ökad kunskap i IT kunskap lyftes upp i flera sammanhang. Regleringen av certifiering styrs till stora delar av ett internationellt regelverk kallat STCW och därför bör alternativa lösningar utvecklas för utbildningen.

Språk: Svenska Nyckelord: Autonomous ships, Education, ICT

OPINNÄYTETYÖ

Tekijä: Björn Pundars
Koulutus ja paikkakunta: Master of Engineering, Turku
Suuntautumisvaihtoehto/Syventävät opinnot: Autonomous Maritime Operations
Ohjaaja(t): Micael Vuorio, NOVIA ja Jouni Lappalainen, TRAFICOM

Nimike: Autonomous Shipping in changing the structures - Future implications on Maritime Education and Training

---

Päivämäärä 20.05.2020 Sivumäärä 58 Liitteet 3

Tiivistelmä

Uutta teknologiaa kehitetään ja implementoidaan merenkulkuun. Tavoitteena on, että tulevaisuudessa käytössä on itseohjautuvia (autonomous) aluksia. Tämä vaikuttaa moneen eri asiaan, lainsäädäntöön, ihmisten käyttäytymiseen sekä koulutukseen. Lopputyössäni "Autonomous Shipping is changing the structures", arvioin miten uudistus vaikuttaa alan koulutukseen. Tutkimustyö edistää Liikenne- ja viestintäministeriön (TRAFICOM) ja Aboa Maren (NOVIA) jo käynnissä olevaa työtä. Tutkimukseni tutkii miten jatkossa voimme kehittää itseohjautuvien alusten vaikutusta merenkulkualan koulutukseen ja sen rakenteisiin.

Tutkimukseni analysoi tutkimusta neljällä alueella: 1) Lainsäädäntöä ja sääntelyä, 2) Kauko-ohjattavuutta, 3) Ihmistekijöitä ja 4) Koulutusta. Tutkijat ovat todenneet, että tarvitaan muutoksia tai sovittamista, kun itseohjaavien laivojen operoiminen aloitetaan. Empiiristä osaa varten haastattelin kuuttatoista alan, viranomaisten ja koulutuslaitoksen henkilöä.

Tulokset osoittavat, että tutkimus ja haastatteluiden anti tukevat toisiaan. On olemassa monta ratkaisematonta asiaa, ei pelkästään teknisiä asioita. IT-osaamisen lisääntyvä tarve tuotiin useassa yhteydessä esiin. Kansainvälinen säännöstö, STCW ohjaa pitkälti sertifioitua koulutusta ja siksi koulutuksen vaihtoehtoisia ratkaisuja on kehitettävä.

Kieli: Suomi Avainsanat: Autonomous ships, Education, ICT

MASTER'S THESIS

Author: Björn Pundars
Degree Programme: Master of Engineering
Specialization: Autonomous Maritime Operations
Supervisor(s): Micael Vuorio, NOVIA and Jouni Lappalainen, TRAFICOM

Title: Autonomous Shipping in changing the structures - Future implications on Maritime Education and Training

---

Date May 20, 2020 Number of pages 58 Appendices 3

Abstract

The aim is to have autonomous ships in the future as well as new technology developed and implemented in the maritime sector. This will have an impact on many issues like legislation, human factors, education and training. Within this thesis "Autonomous Shipping is changing the structures", I will focus on implications on Maritime Education and Training. The research work will be a contribution to Autonomous Shipping related work at Finnish Transport and Communications Agency (TRAFICOM) and at Aboa Mare (NOVIA). My research will look at the the ongoing development within Autonomous Shipping impact the structure and maritime education.

My research will analyse research done in four areas: 1) Legislation and regulatory, 2) Remote operation, 3) Human factor and 4) Education and training. Researchers have stated that changes or adaptations will be required when we start operating autonomous ships. People (16) from business, authorities and educational institutions where interviewed for the empirical part of this Thesis.

The results show that research and the input from the interviews support each other. There are many unresolved issues, not only technical ones. Increasing the IT knowledge in maritime education came up in many contexts. The international regulation, called STCW, is regulating the certificate education to a high extent and therefore alternative solutions need to be developed for education.

Language: English Key words: Autonomous ships, Education, ICT

ACKNOWLEDGEMENTS

One reason for applying to the Autonomous Maritime Operation Master's program is my interest in the sea, ships and navigation which started already in my childhood. The second reason is that during 2013-2017, I completed the Bachelor's of Marine Technology within the Degree Programme in Maritime Studies and this gave me more energy and motivation, for further studies within the field. The third reason is related to my background and experience, having more than 20 years' of experience from Information Management in industry and educational sector, being involved in technology development and IT.

In late spring 2019, I started the discussion with the Finnish Transport and Communication agency, short name is TRAFICOM, for writing my thesis and the subject I was interested in. There was a common interest from both parties in the subject and later that spring this resulted in a mutual agreement, on writing my thesis for TRAFICOM. During my summer vacation in 2019, I conducted the majority of my interviews. Putting it all together and writing the thesis has taken quite a long time, as normal work needed a lot of attention as well as the AMO course assignments. My thesis project is coming to an end and I want to make my humble appreciation to all the people that have supported me in this project.

My supervisor; Jouni Lappalainen, Special Adviser at TRAFICOM, who supported me in the most encouraging way, giving constructive suggestion how to improve my work and also provided me with useful contacts and guidelines.

Secondly Mr. Micael Vuorio, Head of Maritime Academy and Training Center Aboa Mare, Vice Dean Technology and Seafaring Novia UAS, acting as my supervisor at NOVIA.

Thirdly, I want to express my appreciation to Barbro E. Schauman, Senior Lecturer at Åbo Akademi University, who encouraged and supported me during the whole process.

Fourthly, all the people I interviewed and their engagement in and passion for the discussions and the time they spent on them. I will mention them by name in chapter 4.1.

Fifth, my opponent Emmet Ryan, who supported me with valuable information in my work.

Finally, a humble big thanks to the AMO student group, the DreamTeam, it has been great getting to know you and work with you. Let's keep in touch.

Kalmar, 20th May 2020

Björn Pundars

Table of contents

1 Introduction

The ongoing discussion and development in the media related to digitalisation and automation, also makes the Maritime sector interesting. Regardless of which role one has or operation one is involved in, safety comes first and is the top priority within shipping. On board ships you often hear that safety should always come first. The shipping sector is learning from experience, maintenance is essential but proactive steps are also taken. Information gathered from incidents, rules and legislation is changed accordingly, targeting to improve the safety in all shipping related operations.

In addition to safety concerns, the development related to digitalisation and increased automation, also raises the concern regarding unemployment. Automation does not necessary lead to unemployment, it may also create new jobs, and work profiles might be changed. This will also require changes in the education sector, to support the development of new technology and more automated equipment, but will also offer good possibilities to support life-long learning or continuous learning. In this context life-long learning and continuous learning are used as synonymously, and defined as basic education e.g. master marine degree and whatever education is completed after the first degree. Life-long learning should be considered a concept which never ends, the environment is changing, new technologies are coming and we need to educate ourselves to be able to cope with those challenges.

It is also vital that we continuously do research in the field, not only for improving safety issues, but also adapting requirements regarding legislation, medical, certificates, qualifications, education and training issues. Close cooperation between all stakeholders in the Maritime sector is needed for successfully implementing the above mentioned elements, supporting Autonomous shipping. Stakeholders in this context are e.g. authorities, ship owners, port authorities, educational institutions and the industry together with governance organisations like the International Maritime Organization (IMO) and national authorities like the Finnish Transport and Communications Agency (TRAFICOM).

The purpose of this thesis is to investigate how the effects from the ongoing Autonomous Shipping activities will impact the Maritime sector in a near future, with a special focus on the education and training part. The thesis is a contribution to the research work, related to Autonomous Shipping, going on at The Finnish Transport and Communications Agency and at Aboa Mare, which is a Maritime Academy and Training Center educating maritime professionals (Aboa Mare, u.d.), at NOVIA, University of Applied Sciences.

1.1 Background

Shipping should be seen as one part of the whole logistical chain, which includes all the operations from safety, loading, unloading, mooring, reporting to operating and transporting either passengers or goods. For centuries shipping has played an important role as a transportation mode. With shipping in this context, I mean ports and related activities, e.g. loading, unloading passengers or goods. Shipping serves many purposes, first of all it is a way to travel between different locations, secondly it is a way to transport goods and thirdly it is providing different kind of service e.g. ice-breaking or tug operations.

During the shipping history the type of ships, have been developed and evolved, sizes has increased as well as material and equipment, but also legislation has been adopted accordingly. This development will continue due to the fact that digitalisation and automation will increase in the coming years. Economic efficiency operating a ship and supporting legislation e.g. Sulphur limits (International Maritime Organization, 2018) and autonomous ships will also require rethinking in design and materials regarding both old and new ships. New built ships are always easier to equip with new technology, appliances and applying to new legislation compared to converting old ships. Restructuring costs for complying can be extremely high despite that quite long transition periods are allowed, e.g. supporting the sulphur directive.

Compared to the aviation industry, which standardises plane types, due to only a few manufacturers, building ships is far from reaching the same standardisation level. This means that ships are unique objects, although they sometimes are called sister ships, as part of a small series production of two or more ships, they are still different. The uniqueness means that each ship is built as an individual vessel, and the same amount of standardisation and modularisation is not achieved as in the aviation business. The result is that building a ship is a valuable asset and cost efficiency can't be reached compared to aviation or automobile industry. Building a ship may cost hundreds of millions of Euros, depending on the size, and equipment, partly due to lack of mentioned standardisation, but also due to the regulatory requiring constructions which are safe.

"*The International Maritime Organization (IMO) is a specialized agency of the United Nation's with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships*" (International Maritime Organization, 2019).

"*The Organization consists of an Assembly, a Council and five main Committees: the Maritime Safety Committee; the Marine Environment Protection Committee; the Legal Committee; the Technical Cooperation Committee and the Facilitation Committee and a*

number of Sub-Committees support the work of the main technical committees" (International Maritime Organization, 2019).

The Maritime Safety Committee, short name is MSC, is of special interest, when we talk about Autonomous shipping, a committee addressing AS related issues. During the MSC 98th session a scoping exercise on autonomous vessels, was added on the agenda, having with the focus on determining safe, secure and environmental operation of Maritime Autonomous Surface Ships, introduced in the IMO instruments (International Martitime Organization, 2017).

In the MSC 99th session, the Committee endorsed a framework for a regulatory scoping exercise. This exercise should take care of defining MASS and degrees of autonomy, as well as a methodology for conducting the exercise and a plan of work (International Martitime Organization, 2018). "*For the purpose of the regulatory scoping exercise, Maritime Autonomous Surface Ship is, defined as a ship, which, to a varying degree, can operate independently of human interaction*" (International Maritime Organization, 2018).

The MSC 100th session defined the degree of autonomy for the purpose of the scoping exercise.

Autonomous shipping has been discussed and developed actively for several years. Projects like the Maritime Unmanned Navigation through Intelligence in Networks, abbreviation used is MUNIN, co-founded by the European Commission and executed between 2012 and 2015, together with and Advanced Autonomous Waterborne Applications Initiative (AAWA), 2015-2017 have been forerunners, generated other researchers write articles related to autonomous and remote controlled ships (AAWA Position Paper © Rolls-Royce plc, 2016). Research work has been done on many areas e.g. human factor, legal issues, remote operating, education, rules, safety and unmanned operations. This work has raised the Autonomous ship issue as an important topic for IMO, and especially for the MSC. The Maritime Safety Committee holds regular sessions, considering relevant shipping topics to be addressed.

Table 1 on the next page shows an adapted version of the degrees.

Degree	Description	Operators role
1	Ship with automated processes and decision support	Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.
2	Remotely controlled ship with seafarers on board	The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.
3	Remotely controlled ship without seafarers on board	The ship is controlled and operated from another location. There are no seafarers on board.
4	Fully autonomous ship	The operating system of the ship is able to make decisions and determine actions by itself.

Table 1: Adapted from MSC 100th session (International Maritime Organization, 2018).

The word autonomous is used in many different contexts e.g. manned, unmanned, partly manned, and therefore clarification was needed to done by IMO, for clarifying and easing the discussion with different stakeholders.

The Norwegian Forum for Autonomous Ships (2017) have made definitions for ship autonomy types as, shown in Table 2.

	Manned bridge	**Unmanned bridge - crew on board**	**Unmanned bridge - no crew on board**
Decision support	Direct control No autonomy	Remote control	Remote control
Automatic	Automatic bridge	Automatic ship	Automatic ship
Constrained autonomous	-	Constrained autonomous	Constrained autonomous
Fully autonomous	-	-	Fully autonomous

Table 2: Ship autonomy types, source: Norwegian Forum for Autonomous Ships (2017).

Articles often refer to the NFAS definition e.g. Ramos et al in their article "*Collision avoidance on maritime autonomous surface ships: Operators' tasks and human failure events*". (Ramosa, Utnea, & Mosleh, 2019)

Classification societies (responsible for creating and maintaining technical standards regarding ships and its operation) have made their own definition and e.g. Bureau Veritas's Guidelines for Autonomous Shipping, which shows in a clear way the ship type, the human interaction versus level of autonomy is described in table 3.

Ship category	Level of Autonomy		Manned	Definition	Authority to make decisions	Actions initiated by
Conventional	**0**	Human operated	Yes	Automated or manual operations are under human control	Human	Human
Smart	**1**	Human directed	Yes/No	Decision support Human makes decisions and actions	Human	Human
Autonomous	**2**	Ship category	Yes/No	Human must confirm decisions	Human	System
	3	Human supervised	Yes/No	System is not expecting confirmation Human is always informed of the decisions and actions	Software	System
	4	Fully autonomous	No	System is not expecting confirmation Human is informed only in case of emergency	Software	System

Table 3: Ship categories and level of autonomy (Bureau Veritas, 2017).

The Danish Maritime Authority (2017) produced a report named "Analysis of regulatory barriers to the use of autonomous ships", which is using the definition of Lloyd's Register's for autonomy.

The Danish Maritime Authority's report "*is based on differences between the technique used as well as the operator's role*". It is important that the definitions are clear for the reason of communication and understanding, otherwise there is a risk that we mix things or misunderstand.

There are many actions supporting both digitalization and autonomous shipping, the first example is the regulation allowing ships to keep a logbook electronically (Finnish Transportation and Communication Agency, 2017). The system provider need to have approval from TRAFICOM. The combination of a password protected personal accounts allows for electronic signatures. The logbook should be stored in a minimum of two locations in order to secure availability and disaster recovery.

The second example is the automated vacuum system functioned mooring (auto docking or auto mooring) handling in the port of Tallinn, Estonia. According to Port Captain Ronny Eriksson, a similar one was implemented for the port of Långnäs, Åland, within one to two years (Hildén, 2019). This technology is also implemented in other ports e.g. Trelleborg, Sweden. According to Ship technology (2019) the next generation of auto mooring system will be magnetic based, but these are currently in a development phase. The vacuum-pad system should be fully functionally, proof and safe in conditions up to 15 m/s windspeed. Auto mooring will decrease the number of accidents as work force will not be needed physically in certain activities, e.g. mooring operations and there is a risk that a rope may break and cause injuries or damages.

Mooring during hours of darkness has the risk of a crew fatigue and in the future, when the auto-mooring concept is accepted and implemented, it will change the need for crew waking up in the middle of the night for mooring operations.

The third example is the test area called Jaakonmeri, in the South West of Finland, an area where new technology, related to autonomous ships, may be tested. The test area "Jaakonmeri" is located in the SW part of Finland and shown geographically in figure 1.

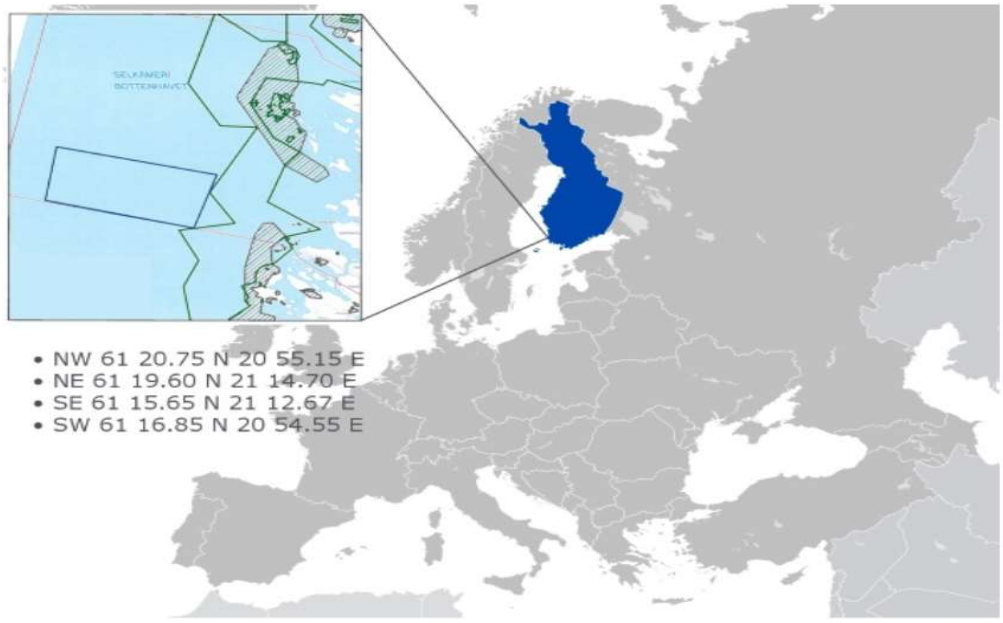

Figure 1: Location of the test area Jaakonmeri, source: Digital, Internet, Material & Engineering (2017).

The test area Jaakonmeri was opened in August 2017 and Digital, Internet, Materials & Engineering Co-Creation, abbreviation used is DIMECC, is offering the connectivity to the area (Digital, Internet, Materials & Engineering Co-Creation, 2017).

Norway has also opened a test area in late 2017, which is located in the area of Trondheim and Horten, especially to be used for the Yara Birkeland project (World Maritime News, 2017).

1.2 Statement of purpose, research questions and research approach

The Thesis studies how the global transformation of the maritime business, with focus on education, can be made easier from today's system, towards Autonomous Systems, and what changes are needed in education for supporting that development.

The first purpose of this study is to analyse relevant research in the area of autonomous shipping. The MUNIN and the AAWA projects have been pathfinders in autonomous shipping research, the two projects has resulted in a lot of continuous research related to subjects such as human factors and remote operating.

The second purpose is to study which changes in education will be required. My research data consists of interviews with people from the marine business, all having a long experience from the maritime sector. The interlocutors are 16 and they work in the industry, on board, authorities or in an educational maritime institution.

This research will focus on the following research questions:

- What is Autonomous Shipping (AS) and what are the implications for the structure?
- How will AS impact maritime education?

The first research question is based on possible implications on the structure, when the development within shipping produces and drives for increasing the automation and more integrated systems. This will impact the way of working, qualifications, roles, responsibilities and the behaviour. Things done manually today becoming automated in the future, will change how to act, the structures, education and training. Previous research on automation and robotics has shown that automated work activities improve safety, but this has required modification in work profiles and responsibilities.

The second research question is investigating if there is a need for changes in education, what kinds of changes are required and how the transformation, can be done easier, from today's system to autonomous systems.

1.3 Structure of the Thesis

This research work is structured as follows: Chapter two, is the theoretical part of my thesis and will explain the maritime system, containing relevant research within the autonomous shipping. Governmental strategical points, relevant to digitalisation and life-long learning will be brought forward. Educational issues will be limited to the deck officer study structure and the framework for seafarer education using the information from Aboa Mare. The majority of the training is regulated by the STCW, which gives certain rules and guidelines, which need to be followed and set targets achieved. The STCW is regulating the content to a large extent, and which STCW courses need to be studied including the course content, in a degree program.

Chapter three will discuss the methodology behind my thesis. This will include the choice of methodology, data collection, selection and analysis. Chapter four will present the result of the interviews.

The main questions used in the interviews are presented in chapter five, and they are:

1. What is Autonomous Shipping (AS)?
2. What structures need to be changed due to the realisation of AS?
3. What is your opinion on how AS will affect people's behaviour?
4. What is your perspective on education?
5. How will AS change the maritime business?

The interlocutors and the organisation they are representing, will be presented briefly in chapter four, with the interviewee's permission.
Finally, in chapter five I will write the conclusions, discuss and make recommendations, and provide questions for further research.

2 The Maritime system

"*The International Maritime Organization (IMO) is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships*" (International Maritime Organization, 2019). IMO is the owner of STCW, stipulating rules and guidelines for maritime training. STCW has been ratified by more than 130 countries.
Several conventions regulates the operation and maintenance of shipping, in the context of autonomous shipping and legislation.
The below list is limited and not complete:

- The Safety of Life At Sea convention (SOLAS).
- The International Convention of Standards of Training, Certification and Watchkeeping for Seafarers (STCW)
- Convention on the International Regulations for Preventing Collisions at Sea (COLREG)
- The International Convention for the Prevention of Pollution from Ships (MARPOL)
- The International Convention on Maritime Search and Rescue (SAR).

The above list will be discussed in chapter 2.3.1 Legislation and regulatory.

In this context, the maritime system, which will cover the theoretical part:

- Governmental strategies on digitalisation and life-long learning
- The Maritime education
    a. The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW)
    b. Complementary training
- Research within the Autonomous shipping area
    a. Legislation
    b. Remote operation
    c. Human factor
    d. Education and training

The above listed elements are significance to the work of this Thesis, looking at the research published in the area in question.

2.1 Governmental strategies on digitalisation and life-long learning

There are Governmental strategies on digitalisation and life-long learning, which gives a framework and guidance for organisations, like The Finnish National Agency for Education, and the Finnish Transport and Communication Agency (TRAFICOM), who are making concrete actions plans on how to support the strategies.

In this context with Governmental, is meant European Union and Finnish Governmental organisations, which in their strategies have pointed out digitalisation or education related actions, which is relevant for Autonomous shipping when new technologies are implemented and developed.

The European Union has a strategic framework for European cooperation regarding education and training, where education and training have a crucial role in meeting technical challenges facing Europe and its citizens today and in the future. Making life-long learning and mobility a reality, and improving the quality and efficiency of education and training is part of the EU framework (European Union, 2019). Individuals should understand how digital technologies can support communication creativity and innovation and be aware of their opportunities, and with the digital competence should be able to critical engagement for learning at work and participation in society, including safety understanding, problem solving and critical thinking (European Union, 2019).

A new Government was elected in Finland in spring of 2019. One of the major tasks, for the Government, is to agree on a four year Governmental program.

This program is called the Finnish Government Programme (2019) and was done in Quarter 2 and amended in December 2019. Strategic guidelines included in the program is used by other institutions, e.g. TRAFICOM, Ministry of education and educational institutions, when making their own plans.

The existing program points out a couple of interesting things regarding digitalisation and education. The first thing promoted is focusing on digitalisation, regarding educational and society services. The second thing is the importance of life-long learning and promoting it through the whole life. The Ministry of Transport and Communications is also promoting digitalization, in their maritime strategy for 2014-2022.

The Ministry's strategical vision for 2030, is "*A prosperous Finland – smart sea routes*" (The Finnish Government, 2014). TRAFICOM supports the development, which can be seen e.g. with Jaakonmeri and the electronic logbook, described in chapter 1.1.

Eva Mark (2009) is looking at life-long learning, from an educational point of view. Mark defines it as something, which will support building the individual competence and the society's knowledge. According to Mark (2009), the motivation for promoting life-long learning relates to the need to face the different environmental changes, which fits very well to the existing development within shipping and Autonomous vessels. Being able to support these changes Mark (2009) recommends different and new ways of teaching, by building bridges between different teaching contexts. She recommends that it will be required to offer studies at different speed, courses outside working hours and from different locations.

The Finnish Innovation Fund Sitra, SITRA (2019) recommends in their report that "*we must dare to rethink what the best way of producing competence is*" (The Finnish Innovation Fund Sitra, 2019). Towards Lifelong Learning. SITRA highlights that we are already in a situation where the alternation and overlapping of work and learning is characteristic.

"*Improving competence cannot mean completing a new qualification or part of a qualification each step of the way, but, in the future, it must be made possible for everyone to combine education, work and spare time into a goal-oriented entity of learning*" (The Finnish Innovation Fund Sitra, 2019).

2.2 The Maritime education

"*The STCW Convention was the first to establish basic requirements on training, certification and watch keeping for seafarers on an international level. Previously the standards of training, certification and watch keeping of officers and ratings were established by individual governments, this was usually without reference to practices in*

other countries" (International Maritime Organization, u.d.). In 1995 and 2010 major revisions were made as amendments.

There are four institutions or schools arranging Maritime education in Finland, they are located in Turku, Kotka, Rauma and Mariehamn on the Island of Åland.

My thesis will be limited to the deck officer program and the school in Turku, Finland, which is Aboa Mare, a Maritime Academy and Training Center educating maritime professionals (Aboa Mare, u.d.), at NOVIA, University of Applied Sciences (UAS).

Studies are divided into academic years, and each course is given study points, called credits. Credits are defined by the European Credit System (ECTS) (European Commission, 2015). ECTS defines that one academic year includes 60 credits (Studyportal Masters, u.d.), which gives 4.5 years complete the examinations as a deck officer, including the mandatory sea time. According to ECTS, 60 credits require between 1500 and 1800 hours of full time studies, which includes lectures, assignment, exercises and self-studies.

IMO has a model course programme, which aims to support the maritime training institutions (International Maritime Organization (IMO, 2015). The model course description contain objectives and details on delivering a course and its targets.

On passing a STCW course a certificate is awarded, which for most not all, are valid for five years and prolonging the validity of a certificate, it will require a refresher course to be completed.

2.2.1 The International Convention on Standards of Training, Certification and Watch keeping for Seafarers - STCW

"*The 1978 STCW Convention was the first to establish basic requirements on training, certification and watchkeeping for seafarers on an international level*" (International Maritime Organization, u.d.). The Convention consist of articles, which outline the legal responsibilities a party has to meet.

"*The Standards of Training, Certification & Watchkeeping convention (STCW 1978 as amended) – as one of the key instruments of International Maritime Organisation (IMO) in regulating the minimum qualification for seafarers worldwide – provides the global benchmark for training of seafarers*" (Sharma, Kim, Nazir, & Chae, 2019).

"*The provisions of the Convention not only apply to seafarers, but also to ship owners, training establishments and national maritime administrations*" (Safety4sea, 2019).

"*A key aspect of the STCW Convention is that mandatory education and training is required for all certificates of competency as master, deck and engineer officer and radio operator*" (Fisher & Muirhead, 2019). This applies also for ratings e.g. Able Seaman.

The Convention and the Code includes instructions, concerning the majority of the maritime courses, provided by the educational institutions. IMO has made descriptions of model courses, which are usable as guidelines for setting up courses, by the institutions.

The Convention is an agreement between countries which is governed by international law. The Annex in the Convention consists of Regulations divided into chapters and they are:

- Chapter I: General provisions
- Chapter II: Master and deck department
- Chapter III: Engine department
- Chapter IV: Radio communication and radio personnel
- Chapter V: Special training requirements for personnel on certain types of ships
- Chapter VI: Emergency, occupational safety, medical care and survival functions
- Chapter VII: Alternative certification
- Chapter VIII: Watchkeeping (International Maritime Organization, u.d.).

Each chapter contains details on requirements needed for a specific topic or role.

"*Generally speaking, the Convention contains basic requirements which are then enlarged upon and explained in the Code. Part A of the Code is mandatory. A series of tables is showing the minimum standards of competence required for seagoing personnel. Part B of the Code contains recommended guidance which is intended to help Parties implement the Convention*" (International Maritime Organization, u.d.).

"*The measures suggested are not mandatory and the examples given are only intended to illustrate how certain Convention requirements may be complied with*" (International Maritime Organization, u.d.).

Tables covering the qualification details, e.g. the table for Navigation qualification at the operational level, described in figure 2, on next page.

	STCW Code Tabel A-II/1		
Specification of minimum standard of competence for officers in charge of a			
	navigational watch on ships of 500 gross tonnage or more		
	Ref: https://www.edumaritime.net/stcw-code		
	Source: http://www.imo.org		
Function: Navigation at the operational level			
Column 1	**Column 2**	**Column 3**	**Column 4**
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating**	**Criteria for evaluating competence**
Plan and conduct a passage determine position	*Celestial navigation* Ability to use celestial bodies to determine the sip's position *Terrestrial navigation* Ability to determine the ship's position by use of: .1 landmarks .2 aids to navigation	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training, where appropriate	The information obtained from nautical charts and publications is relevant, interpreted correctly and properly applied. All potential navigational hazards are accurately identified The primary method of fixing the ship's positio is the most appropriate to the prevailing circumstances and conditions
.....	.....	.....	.....

Figure 2: STCW Code Table A-II/1 – International Maritime Organization (2019).

The STCW code table shows the competence, knowledge as well as methods for demonstrating the competence and criteria's for evaluation.

One interesting thing regarding simulator usage is that "*STCW only makes the use of simulators mandatory for Radar and Automatic Radar Plotting Aids (ARPA) training*" (Fisher & Muirhead, 2019).

2.2.2 The Finnish maritime education

Maritime education, which in this context is limited to the deck officer education, or the Bachelor of Marine Technology (Master Mariner) degree, as part of NOVIA's education program, planned and executed by Aboa Mare. The three other maritime institutions, Kotka, Rauma and Mariehamn, is also following the STCW standard as well and each school has some area of specialisation.

The Bachelor of Marine Technology or master mariner program is giving 270 credits or ECTS, and planned to be completed in 4.5 years, including mandatory sea training. This is based on one academic year, defined as 60 credit of full time studies. According to ECTS, 60 credits require between 1500 and 1800 hours of full time studies, which includes lectures, assignment, exercises and self-studies. Out of the 270 credits, 78% is directly, related to STCW, and the remaining 22% is not regulated by STCW.

However, the "free" courses are designed to support the STCW courses and skills e.g. courses in mathematics and chemistry.

Sea training is defined as guided or supervised training for 360 days, this is a requirement for achieving the Bachelor degree and the Deck Officer certificate. Collecting the sea days can be done in steps/parts, with accumulated sea days totalled together. The education program is planned in such a way, that it is able to collect sea days during the 4.5 year of studies. The study plan has designated times, lecture free, when sea days should be collected. The legislation, 166/2013 (Finnish Ministry of Justice, 2013), regarding manning, is stipulating requirements for watchkeeping officers. §23, 3.1.b says "*that a maximum of one (1) months simulator training can be included in the 360 days needed for the guided training in addition to the theory parts*". This has been available for approximately five years, and notable is that this possibility is not an option in the Swedish maritime education system. The simulator exercises seems to be a good strategy considering the development potential of remote operated centres. During 2012 and 2014 there was a modification of the courses, which lead to a higher amount of credits for sea training, from 60 to 108 credits, and instead there was a reduction of basic modules or courses, not STCW regulated courses.

The structure of the not STCW regulated courses generates 59 credits earned and they are modularised as follows:

- Five credits is voluntary, and can basically be any academic course
- 39 credits is related to basic studies, e.g. introduction, mathematics, languages
- 15 credits is related to writing the thesis.

It is notable that the basic studies includes one IT course, credited 1.5, and the course competence provides knowledge in word processing, spreadsheet management, presentations and data communication, useful knowledge for different course assignments and writing the thesis. It is notable that, for approximately four years, in Finland it has been mandatory for the students going to high school to have a laptop to be used for their matriculation tests, which are now done electronically. Therefore one could assume that IT skills should be more than the basic level.

In addition to the Bachelor degree for master mariners, Aboa Mare has two (2) Master degree programs, "*executed as part-time studies, in parallel with fulltime employment ashore or at sea*" (NOVIA, University of Applied Sciences, 2019). These master program has a planned extent for two years, giving 60 ECTS each, meaning they do not require full time studies.

The Master degree programs at the moment are:

- Master of Engineering/Master of Maritime Management
- Master of Engineering, Autonomous Maritime Operations (NOVIA University of Applied Sciences, u.d.).

Aboa Mare also provides VTS (Vessel Traffic System, which is monitoring vessel traffic) course packages, and single courses on specific subjects e.g. Maritime Cyber Security.

NOVIA announced on the 8th of January 2020, in a press release that they will start planning a degree program for educating sea engineers, leading to a Bachelor of Engineering, Maritime Technology (Yrkeshögskolan NOVIA, 2020).

2.3 Research within the Autonomous shipping area

Man (2018) states that research for military autonomous vessels has been going on for years, but information is not always publicly available. Hult et al (2020) concludes in their report "Autonomy and responsibility" that the type of operations and sea area surroundings will drive the technology to be used onboard ships, not the other way.

The MUNIN and the AAWA project generated a lot of new research in many areas e.g. human factor, remote operation and legislation. "*The project MUNIN – Maritime Unmanned Navigation through Intelligence in Networks – is a collaborative research project, co-funded by the European Commissions under its Seventh Framework Programme. MUNIN aims to develop and verify a concept for an autonomous ship, which is defined as a vessel primarily guided by automated on-board decision systems but controlled by a remote operator in a shore side control station*". (MUNIN, 2016) The project timeframe was between 2012 and 2015.

"*The Advanced Autonomous Waterborne Applications Initiative (AAWA) combines members from academia and the maritime industry to produce specification and preliminary designs for the next generation of ships*" (AAWA Position Paper © Rolls-Royce plc, 2016).

Both projects have achieved major research milestones and continue working on related to Autonomous Shipping issues.

A recent published conference paper by Hynnekleiv et al (2020) on "*Towards an ecosystem of skills in the future maritime industry*" as part of the Human Autonomy Enable (HUMANE) project, bring up which skills will be important in the future. The result brought up the following areas: IT and cybersecurity literacy, Emergency response, Tool handling,

Communication, Seamanship, Well-trained & multi-skilled and safety awareness (Hynnekliev, Lutzhoft, & Earthly, 2020).

2.3.1 Legislation and regulatory

There are several conventions regulating the operation and maintenance of shipping, in the context of autonomous shipping and legislation. The below list is limited and other exists:

- The Safety of Life At Sea convention (SOLAS).
- The International Convention of Standards of Training, Certification and Watchkeeping for Seafarers (STCW)
- Convention on the International Regulations for Preventing Collisions at Sea (COLREG)
- The International Convention for the Prevention of Pollution from Ships (MARPOL)
- The International Convention on Maritime Search and Rescue (SAR).

SOLAS specifies the acceptable standards for the construction, equipment and operations. Operating a ship requires certifications, verifying the fulfilling of all regulation, issued certificates and inspection, which is conducted by the Flag State, who will ensure that standards are met. The manning of the ship including the obligations and procedures in a distress situation is regulated in chapter V. Chapter I says, *"....shall be sufficiently and efficiently manned…*" and "*shall be provided with an appropriate minimum safe manning document or equivalent*" (International Maritime Organization (IMO), 2014).

This does not exclude autonomous ships without crew, but in such a case the rule must be adapted, as the rule where originally made for manned ships.

SOLAS chapter XI-2 includes the International Ship and Port Facility Security (ISPS) Code, which defines security offers and personnel, but lack of referring to autonomous ships. Komianos (2018) proposes that one solution could be to exclude this obligation from deep-sea navigation, by defining areas close to the port for security check before allowing the ship to continue outbound. SOLAS chapter IX, contains the International Management Code for the Safe Operations of Ships and for Pollution Prevention (ISM code), and it requires a safety management system, which aim to prevent human injury or loss of life. An unmanned vessel would not face these issues, as it is envisioned that there will be no persons onboard.

The STCW covers manned vessels, but do not a cover a person ashore, remotely operating a ship. "*These personnel are not regulated by STCW, although they have been delegated the authority to control Autonomous ships*" (Komianos, 2018). Labour law applied for seafarer

would possible need to be adjusted for operators, working ashore in an office like environment.

The international rule for preventing collision at sea, COLREG, covers especially two (2) rules which need to be further discussed or adapted; 1) Rule #2 Responsibility, the definition of master and belonging responsibilities.

The Captain of the ship is currently responsible, but how about when we have an operator running the ship from ashore? 2) Rule #5 Look-out, says "proper look-out by sight and hearing" and using all available means. This rule might be fulfilled with technical equipment like sensors, audio, cameras, lidar, but the discussion need to continue, also regarding the importance of human senses and how technology or Artificial Intelligence (AI) might replace that.

The International Convention for the Prevention of Pollution from Ships (MARPOL) sets standards for preventing pollution. An autonomous, unmanned ship, would not generate any garbage of trash for disposal as no humans would be on board.

The International Convention on Maritime Search and Rescue (SAR) regulates rescue of persons in distress and the obligation of ships assisting vessels in distress. The SAR convention has no reference to autonomous ships at the moment.

The IMO has identified the Autonomous issues in their strategic plan for 2018 to 2023 and the "*the Regulatory scoping exercise for the use of Maritime Autonomous Surface Ships (MASS)*" (International Maritime Organization (IMO), 2017) is one example on activities in progress. The first major event was The International Conference on Maritime Autonomous Surface Ships, held 2018 in Busan, republic of Korea. Since then many groups have been working on issues related to the new development and technology related to autonomous shipping, but also on related elements like human factors and legislation. IMO's Legal Committee is one group who has the topic on its agenda.

The Danish stakeholders, Cefor and Core Advokatfirma, is a group looking in to legal related issues. In their report "*Zooming in on civil liability and insurance*", they point out the importance of defining and using the right terminology, concerning what is meant with Autonomous, unmanned or manned or a combination of it. Cefor and Core (2018) is pointing out five perspectives from a stakeholder point of view, of which the Remote Operators in one. Remote control is the biggest "unknown" according to the stakeholders, as there are many unsolved questions e.g. duties, obligation, responsibility and liability. "*A clear distinction between duties and liabilities need to be established*" (Cefor&Core Advokatbyrå, 2018).

The role of the remote operator is central, and different stakeholders have agreed that the remote operators should be included in the Internationally Safety Management code (ISM). The same stakeholders also see a clear need for a regulation for education, training and certification.

Core Advokatbyrå (2018) has in their report "*Maritime Autonomous Surface Ships ("MASS")*", recognised that the research is still in an early stage with MASS legislation and will need further studies.

Stakeholders in the Maritime business sees the lack of international regulatory as the main concern according to Core Advokatbyrå (2018). Their recommendation is that changes to the regulatory should be kept to a minimum and focus should be on updating existing rules not creating new one's if such are not needed.

The liability issue of ship owners and classification societies is seen as another key issue. Regarding the ship owners' strict liability, which today is the case in accidents caused by the operation of ships, e.g. oil leakage.

Core Advokatbyrå (2018) recommends that the data operationally generated should be owned by the ship owners. Achieving that will require contracts including licensing and confidentiality clauses. Regarding the definition and ownership of data, there is at the moment very little public research available.

The fourth issue is the duties and obligations of the master, which need to be clarified according to Core Advokatbyrå (2018), as well as clear definitions for the remote operator. "*Stakeholders see the addition of the remote operator as just another player in an already complex environment*" (Cefor&Core Advokatbyrå, 2018). This recommends that the remote operator's duties are subject to the international law.

Regarding health and safety issue Core Advokatbyrå (2018) recommends that it could be subject to the legislation ashore.

Cyber security risk, is one concern, which is also raised in the report, but this issue is outside the scope of my Thesis.

Vojković (2018) points out the need of many legal challenges due to the use of Artificial Intelligence (AI) during a ships voyage, especially related to the master's role. The speed of technology devlopment and change is fast and there is a risk in general that the legislation will not be able to support it. The master duties being; 1) public authorities, 2) the ship's safety and navigation and 3) representing the shipping company, will need to be put into the light of Autonomous shipping from a legal and practical point of view.

Vojković (2018) sees that the termonology for autonomous and remote operated ships has not yet been defined as final, and the issue still need to be worked on.

The Danish Maritime Authority (2017) made a report, with legal companies Ramboll and Core, on "*Analysis of regulatory barriers to the use of Autonomous ships*". The report identified benefit potentials like cost savings, environmental friendliness due to fuel savings, improved safety and improving the whole logistical chain.

The target of the report was to give recommendations how to handle the regulatory challenges coming up with the development of autonomous ships.

"*The regulatory approach to autonomous shipping should be considered carefully to prevent regulation from becoming a hindrance to technological developments and the commercial use of autonomous technologies in shipping*" (Ramboll & CORE, 2017). The report highlights out the importance of tests, and publication of the results, in order to achieve a knowledge base for regulation work. They recommend is that any autonomous ship regulation should be incorporated into the existing regulatory frame, new regulation should only be created where existing framework do not cover autonomous shipping. According to Ramboll et al (2017) suggest that a realistic approach for autonomous ships is that must be as safe as conventional ones.

Test areas have been established in e.g. Norway and Finland, and it is recommended that inspection and rule-making is done on the national level, until the international regulations have been updated. It is seen as important that care is taken in creating national rules until the IMO's approach becomes clear. The recommendation is also that EU and other regional regulation is waiting for the IMO regulation on Autonomous ships. The report further points out that certain definitions need to be revised, like master and manning of the ship.

2.3.2 Remote operation

A lot of research and activities are going on at the moment focusing on remote operating ships, when it comes to layout, roles and the concept itself.

The MUNIN project studied if unmanned ships can sail as safe as traditional manned ships. Part of the project was to build a remote operating location, the concept was called Shore Control Centre (SCC). The simplest, but technically the most difficult, would be to copy the design from a bridge layout to the remote centre, keeping the layout as similar as possible to a manned bridge. The idea behind was to minimise the change in the operating centre, compared to a manned bridge (Porathe T. , Remote Monitoring and Control of Unmanned Vessels – The MUNIN Shore Control Centre, 2014).

Burgmeister et al (2014) sees the shore based control centre as a new entity, which will constantly monitor and control the autonomous operation, and might even take over direct remote control in exceptional circumstances.

The Shore Control Centre would continuously monitor and control the autonomously operated vessel by its skilled nautical officers and engineers. Vojković (2018) points out that full monitoring includes transmission of TV monitoring and radar picture so that the operation centre has sufficient information about the ship and its surroundings to be able to perform remotely operated navigation.

Other roles or functions should be according to Burgmeister et al (2014) 1) an operator, who monitors the operation of one or more ships, 2) a control engineer, in charge of the maintenance plan and assisting the operating regarding technical issues and 3) a SCC Situation Room, with a team that could take over direct remote control in certain situations.

According to Porathe et al (2014) a number of operators would monitor a number of autonomous, unmanned ships and in the MUNIN project one operator would monitor six (6) vessels at the time, based on alarms and irregularities (Porathe, Prison, & Man, Situation awareness in remote control centres for unmanned ships, 2014).

Rødseth (2017) believes that the ongoing development regarding autonomous, unmanned ships will also increase the automation on manned ships and the total staffing of SCC will be less than 1, as one operator should operate several ships.

Although VTS centres do share similarities with the SCC in terms of monitoring vessels and the goal of ensuring safety at sea, their functionality is very different as VTS centres aim to provide information services to the manned ships for on board navigational decision making (IMO, 1997). They do neither control ships directly nor see each individual ship as an "own ship". In addition, VTS is appropriate for management of traffic within a port or an area having high traffic density (IMO, 1997), whereas the SCC is assumed to monitor (and control if necessary) autonomous unmanned vessels during deep-sea voyages.

In a ship-shore system, according to Man (2018), regardless of the maturity of the automation, there are still people involved, but within a system organised in a distributed manner, instead of in a centralised monitored way, which will include human factor related issues and they will be analysed in chapter 2.3.3.

According to Rødseth (2017) autonomous ships will need more advanced ICT systems compared to the conventional, manned ships and the systems will be more integrated compared to those solutions we have today.

This will increase the data exchange and the need for standards regarding communicating and sharing of information. The MUNIN project has contributed to development of new IEC (International Electrotechnical Commission) standards for shipboard data networks and ship to shore interfaces (European Commission, 2015).

Rødseth (2017) believes that legislation and social acceptance is an important issue to solve.

"*Legislation will not allow unmanned ships if there is a significant public resistance against it. Societal risk acceptance or adversity is a complex issue and not necessarily related to the actual risk level*" (Rødseth, 2017).

Regarding the challenge with legal and liability issues, Rødseth (2017) recommends that these can easily be solved when operating in national or regional waters, by having a close cooperation with the relevant authorities.

The Danish Maritime Authority (2017), in their report made by legal companies Ramboll and Core sees that depending on the autonomy level the remote operator will act differently. The report recommends that simultaneous decision competence is done on the level where the ship either have or not have crew onboard, while on the autonomous level operators role is presumed to supervise and be on call, in cases human decision making is needed (Ramboll & CORE, 2017). The recommendation is that the operators have minimum complete training for supporting COLREG rule 2, good seamanship, similar as for navigation officers, achieving the STCW requirements. Ramboll et al (2017) is recommending additional competences related to steering an autonomous ship and the equipment in use, and this need to be added into the education and qualifications required.

"*A special issue to be taken into account is how to replace practical seagoing experience by virtual simulator experience*" (Ramboll & CORE, 2017). The STCW stipulates that *"….seafarers serving onboard seagoing ships…*." and Ramboll et al (2017) points out that this wording does not apply for remotely controlled ships, neither manned nor unmanned ones. Addressing and adapting the issue further in STCW for remote operators will be required.

"*Remote operators will presumably be specialised as either operators with navigating tasks and operators with engineering tasks. In the long term, the operator's role will presumably include both elements of the navigating officer's and the engineer officer's functions*" (Ramboll & CORE, 2017). In this connection "*the Danish educational approach with the concept of a "dual officer" 94 will presumably become more common*" (Ramboll & CORE, 2017).

The Danish concept means that you have an officer's certificate for both deck and engine. Finland has a similar certificate for able seamen, a combined certificate with authority for both deck and engine.

"*As a general principle, the remote operator should be considered equal to the master in the merchant shipping act and have the same rights and obligations with the amendments deriving from the nature of the issue*" (Ramboll & CORE, 2017).

Vojković (2018) points out that moving the control to an operator centre will require access to sensors and monitoring of propulsion machinery and navigational equipment on board, giving the operator sufficient information about the ship and its surroundings.

The ability to have all necessary information and a good view of the surroundings is essential for situational awareness (SA).

The importance of a close cooperation between the human and the designer of the system is essential. Ramosa (2019) pointed out the importance of consider the human-system interaction and human failure. "It is vital to understand how operators obtain and maintain SA under such a sociotechnical system and more importantly how the interfaces could impact their subsequent decision-making" (Man, Weber, Cimbritz, Lundh, & MacKinnon, 2018).

Vessel Traffic Service (VTS) has similarities with the SCC, however they monitor and provide information to manned ships, mainly in port and high traffic areas, where SCC focuses on deep sea voyages. The Sea Traffic Management (STM), a EU funded project called MonaLisa, developed a functionality exchanging ship to ship route plan, seen as an improvement regarding safety, but could also support future SCC's concepts (Sea Traffic Management, 2019).

Novia UAS is running an R & D project called MasterSIM, aiming to investigate the requirements needed, coming from digitalization and autonomous shipping, especially related to operating vessels remotely. The Finnish Ministry of Education and some external parties are funding the project. MasterSIM started in June 2018 and will continue until end of 2020 and the target is to develop a Remote Operation Center (AMOC) for use as a research platform and education simulator in remote operations (Aboa Mare, Novia UAS, u.d.).

2.3.3 Human factor

Many studies shows that between 60 and 95% of the accidents is due to human error. People forget, become fatigue or misunderstand, which all impacts our performance and actions. Baxter et al (2011) points out that the process should take into account both social and technical factors. "*Socio-technical systems design (STSD) methods are an approach to design that consider human, social and organisational factors, as well as technical factors in the design of organisational systems*" (Baxter & Sommerville, 2011).

Hollnagel (2012) points out the importance of building systems as they are supposed to do and are reliable.

Research points out that recognizing the interaction between people and technology is important and a close cooperation between all stakeholders, end users, designers and

developers is essential for achieving required goals and provide that the delivered solution works as it is functionally defined.

Surprisingly the term technostress is not mentioned in maritime research articles, but characteristics like fatigue, stress and loosing focus are mentioned.

The term was identified in the 1980's by Craig Brod (1984), who is famous for his book "*Technostress: The human cost of the computer revolution*" (Brod, 1984). Brod (1984) defines technostress as a modern disease caused by computer technologies, and effect the healthy manner of a human being. Studies done by Arnetz and Wiholm (1997) brings out healthy manners as fatigue, headache, restlessness, and impacting on stress in a negative way due to increased workload and long usage of different computer based displays. These are all characteristics of technostress. Raišienė et al (2013) bring up that constant usage of technologies creates a dependency to be connected with others constantly.

Research done by Burmeister et al (2014) brought up stress and fatigue factors, characteristics for technostress, for bridge operators on board ships, pointing out that some of these factors might be reduced from a risk point of view, removing the human errors, but new risks might appear when ships are remotely operated and the model operation is changed. Technostress, and the characteristics of it, is an area which will be important when we develop remote operation centres, considering that the youth of today, the future operators, are "married" to a device.

Porathe et al (2014) discuss increasing safety, as one of the objectives of the MUNIN project. Automation is a major driver in many industries, as well as shipping, and it is able to remove manual steps and minimise mistakes, assuming it has been well tested and approved to be working safely, but automation might bring up new types of errors. The MUNIN project looked into unmanned ships as the possibility for increasing safety and reducing human errors. According to Porathe et al (2014) there will be a need of personal on-board in the near future doing maintenance or repair work. An alternative would be to do maintenance work when the ship is in port, but that might prolong the ships stay in port and increase the costs, important is that the equipment need to be very reliable, which would reduce the need for maintenance.

In a remote operating scenario, operators are still needed for taking care of different tasks, e.g. monitoring, correspondence and communication. An unmanned ship will not take away human factors, but focus can be turned on situational awareness. Automation may bring new, unknown errors into the process, e.g. in case the automation is looking for deviations, humans might stop looking for them, which may open a risk in completely relying on the

automation. Ramosa et al (2019) is mentioning two scenarios, the first where the automation system gives a warning, but do not have a solution, when the operator takes over.
The second situation, which might appear when the automation and the operator disagrees on the action needed.
"*The ship bridge may be unmanned, perhaps in periods, but crew may still be on board, ready to take control when needed*" (Porathe T. et al, 2018). The successful of autonomous unmanned ships will be requiring that there is proof of reliability and that they are tested, approved and safe. The requirement of "backup" systems, in case one system will fail, will be important, as well as multi operating, which then will increase the cost for the equipment. Ramosa et al (2019) proposes to analyse how the human interaction with the system works. The importance of a close co-operation between the human and the designer of the system is essential. "*The risk assessment of autonomous ships operation and collision avoidance models need to consider the human-system interaction and human failure*" (Ramosa, Utnea, & Mosleh, 2019).
Burmeister et al (2014) recommends that a gap analyse is made, and identifying gaps related to communication and information issues, e.g. human – machine interaction and lack of procedures and functionalities for quantifying parameters and reliable information.
Österman et al (2020) points out in their research on "*Occupational safety and health for service crew on passenger ships*", the importance of social intercourse with colleagues on board is important. Due to the high employee turnover in some professions, the way people are sticking together during work and time off has changed. The study indicates e.g. long working hours, little time to rest and unclear boundaries between the social interactions. The researchers recommend that efforts need to be done to develop the work environment and removing the boundaries between departments.

2.3.4 Education and training

Existing public research on education and training is very thin at the moment, and no strong recommendations as to what should be done on a detailed level is available. This is understandable as there are many other issues to be investigated and there are dependencies e.g. with the new technology, the regulations which the education is pendent on. Many researchers' points out that there is a need for update and adaptation due to the development of autonomous ships, but concrete recommendations are missing thus far.
Most likely substantial research, not yet published, is being done and in the future those results will be available.

A common term used for education is MET, which is short for Maritime Education and Training.

Due to new technologies being developed, the surrounding and the environment is changing, adaptation and updates will be needed regarding services and solutions, as well as on education and training.

It is essential to know which qualification and certification is needed for the future, although it is difficult to predict how the future looks and what will be the needs.

"*One of the hardest aspects of professional development of seafarers for the future is to build it on the foundation of the past, but with a vision of what is ahead*" (World Maritime University, 2019).

Baldauf et al (2016) recommends that one of the success factors in education and training is simulator usage in practical training drills and complex scenarios. The target should not only be to achieve regulatory compliance with the simulator exercises, but also be a learning process and an important pedagogic tool in gathering knowledge for the seafarer. Simulator exercises have the advantage that one can run complex and stressful scenarios, which will train the user how to handle safety situations in a risk free environment. According to IMO (2014) "*only competent and well-trained seafarers can ensure safety of life at sea*". The amended STCW (2010) makes simulator training mandatory for Electronic Chart Display and Information System (ECDIS) and Radar (ARPA).

Baldauf et al (2016) sees several benefits from using simulator training, 1) it is a risk free environment and actual real damage to a ship is avoided, 2) it is offering a similar environment compared to the real life at the bridge and 3) it improves the decision making.

Regarding the simulator scenarios Baldauf et al (2016) recommends proactive and forward looking cases rather than backward scenarios, meaning historical cases which has already happened.

New technologies will as Baldauf et al (2016) sees it need improved IT skills due to new systems and increased automation. New methods to support life-long learning, like e-learning methods and tools, which will offer more flexibility and make it easier for the interaction between the lecturer and the student, despite the location, time or device used.

Fonsecaa (2019) is pointing out the importance of bridging technology and the future of maritime education and training (MET), it will create a challenge for the educational institutions but also offer opportunities. The future ships and their technology will be more automated and technical than today, which will require different skills than we offer today.

Fonsecaa (2019) recommends that a close cooperation between educational institutions and other stakeholder in the Maritime sector is needed for building up the future education and training programs.

Sharma et al (2019) and Porathe (2019) sees that many of the manual routines will be automated in the future, and job descriptions will be changed as a result. "*To cope with increasing industrial demand and accelerated technological development, the global standard of maritime training and certification will also require revision and adaption*" (Sharma, Kim, Nazir, & Chae, 2019).

Alop (2019) defines the development as smart shipping and is highlighting that investment in education will be needed and new type of skills be as important as the technology itself. Cosmetic changes to today's education, which is producing education focusing on a specific job, is not enough according Alop (2019) and will not be enough in the future.

Due to the increased digitalisation, Alop (2019) sees that ICT competences are becoming more and more important and the future teachers should not be the ones having exclusive knowledge and skills, but rather the ones who can give advice how to usefully use the available information and share their own experiences.

Baldauf et al (2018) made together with seafarers and non-seafarers a navigational test, where they identified that seafarers try to keep the track with as little deviation as possible, as the non-seafarers where more creative in their problem solving, but violating the traffic rules. In the future creative and innovative thinking will be needed, which might require adaptation in the regulatory.

Sharma (2019) recommends that future research should look more closely into the needed competence for Officer in Charge of a Navigational Watch (OICNW), comparing the existing requirement table against different levels of autonomy.

Erdogan (2017) recommends that due to new technologies, MET should use simulators to reflect real life situations for giving better understanding. Designing holistic education and training programs to meet both professional and academic requirements. E-learning methods for education and life-long learning will offer new study possibilities for seafarers who are far away from the facilities of the educational institution.

Diversification of seafarers' employability paths through collaborative development of competences and certification – DivSea, a project part of the European Erasmus+ program developed a blended learning system and analysed the opportunity of implementation for vocational education and training, which resulted in a E-platform, where participants could improve their knowledge and self-assess their achievements (Belev & Daskalov, 2019).

The platform works as a source of information, from e.g. IMO and Hydrographic Office, but also allows the participants to have interactive communication with the teachers.
Belev et al (2019) concludes that the platform can be used as guide for future career planning and improving skills and competencies.

2.4 Summary

There are a lot of activities going on in autonomous shipping and many stakeholder are involved e.g. IMO, national authorities, ship owners, port authorities and educational institutions. European Commission and national Governments has a strategic plan to increase the digitalisation and the life-long learning, which also benefits the autonomous shipping development. EU and national authorities are partly funding the research project, MUNIN as a good example, triggering other projects and research. There are many issues to be solved, not only technical, e.g. human factor, legislation and regulatory, education and training, qualifications and certification.
On the legislation and regulatory side there are many issues to be resolved, partly as the original rules where created for manned ships, e.g. the master role and responsibility, how to arrange the lookout on unmanned ships and how should the education and training need to be developed for supporting the future and new technologies. Improving safety and achieving cost savings are measurement for the ongoing activities but will require reliable and approved solutions before they are accepted.
At present, activities related to remotely operating ships is a “hot topic”, the MUNIN project called it Shoe Control Centre (SCC) and in the MasterSIM project coordinated by Novia UAS it is called Remote Operation Center (ROC).
Test areas are available for testing out autonomous related ships and equipment.
Limited public research is available regarding education and training, but the need for change and adaptation has raised for further research. Life-long learning and E-learning tools are recommended concepts in offering more flexibility in delivering courses and making participation easier despite physical location or device used.

3 Methodology

I have chosen a qualitative research method for collecting the information for my Thesis, in the form of interviews. According to Bryman (2016), a qualitative research is defined as a research strategy that emphasizes the ways in which individuals interpret their social world.

According to Edwards (2013) the sample must provide the data you need to produce answers to your research questions, and this process is theory driven. Maguire (2017) point out that the data analysis is central to credible qualitative research.

Advantages using a qualitative method is pointed out by Rahman (2017), as producing a thick and detailed description of feelings, opinions and experiences of the interlocutors. The nature of data collected is rich and deep according to Bryman (2016).

According to Maguire (2017) disadvantages seen, is that smaller sampler size raises the issue of generalisability to the whole population of the research argues for using qualitative research.

According to Bryman (2016) qualitative research is too subjective, and the criticism which is raised, is that researchers often rely too much on what is important and what is not, together with a close relationship to the interlocutor and the collected data, based on interviews and opinions is difficult to replicate Bryman (2016).

3.1 Choice of methods

Choosing the research method on what answers one want in the research, is one way of approaching the problem. Typically a qualitative method receives the informant's opinions and view how they see the reality. According to Bryman (2016) the downside is that there is no objective truth in the responses. The target of the method is to get more in-depth information concerning a subject, rather than getting brief and high superficial knowledge. The research process used is the inductive approach. The inductive approach is based on observations and findings according to Bryman (2016). Figure 3 shows the process from observations to theory in an inductive approach, as described by Bryman (2016).

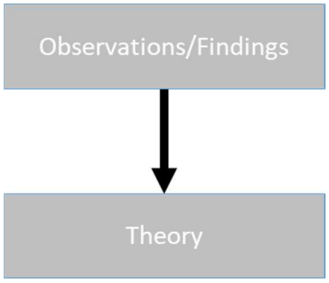

Figure 3: Inductive approach (Bryman, 2016).

Based on the observation a pattern is found, which leads to a hypothesis, supported by a theory. There are three reasons, according to Bryman (2016) for choosing this approach, 1) reaching for more depth, 2) getting a broader view on the autonomous shipping subject from

different stakeholders, 3) utilising my big network of contacts and 4) interviews can be done during vacation time, as the studies are done parallel to normal duties.

3.1.1 Data collecting method

According to Bryman (2016) a semi-structured interview is used, when the questions are defined in advance. The questions are more general but can be taken in various order and additional more specific questions can be asked.

Normally the first question is on a general level and the following questions will be more detailed. Bryman (2016) points out the reason for using the semi-structured interviews 1) having a good picture in advance, of the content to be collected for my thesis, 2) all candidates will get the same main questions, which can equally be evaluated, 3) the interview may partly be adjusted to the candidates interest and knowledge, 4) maximising the time usage available for myself and the candidate, as all have a main job in parallel, 5) giving the candidate a security answering the questions, 6) the interviews is like a discussion and detailed, compared to a hearing, 7) questions makes the interview professional and serious and 8) giving the freedom to focus on things of special importance.

The disadvantages according to Bryman (2016) are 1) is that one has to have a grip of the candidates knowledge and experience, 2) the candidate starts raising things not relevant or the interview is prolonged, and the time is running out, without getting answers to all the questions, 3) misunderstanding or not catching all the information, 4) too subjective, it is doubtful if the researcher knows what is important and what is not and 5) information is difficult to replicate.

3.1.2 Data selection method

A combined data selection method according to Bryman (2016) has been used. Firstly the purposive sampling was used, and secondly a snowball sampling was done. Purposive sampling is defined as “The researcher does not seek to sample research participants on a random basis. The goal of purposive sampling is to sample cases/participants in a strategic way, so that those sampled are relevant to the research questions that are being posed” (Bryman, 2016). This gives the advantage to ask everyone who is easily available, and the researcher’s situation and possibilities steers the sampling. The snowball sampling was used for completing the theoretical sampling. According to Bryman (2016) snowball sampling is used initially with a small group of people, having relevant experience for the research and these participants suggests other candidates. The reason for choosing this approach has the

following advantages; 1) ability to use my wide network of contacts, 2) easy to get commitment from my contacts, 3) easy to recruit people (can work both ways), 4) getting new useful contacts from the social network and 5) a variation may be achieved. Disadvantages are; 1) dependent on the social network, 2) may be sensible for changes over time, opinions might change specially if there is a long time between the interviews (Bryman, 2016).

3.1.3 Data analysis method

According to (Bryman, 2016) the specifics in a thematic analysis is searching for a theme, which is as such useful also in other qualitative data analyses processes.

"Thematic analysis is the process of identifying patterns or themes within qualitative data." (Maguire & Delahunt, 2017) Thematic analysis is useful for novice researchers, according to (Bryman, 2016). It offers a certain flexibility in choosing the theoretical framework. The thematic analyses proposes six steps: 1) Getting acquainted with the data, 2) defining codes, 3) looking for themes, 4) reviewing the themes, 5) defining, naming the themes and 6) writing the report. The reason for choosing the thematic analyses is that it is: 1) a good method for a novice researcher 2) including a certain amount of interpretation and 3) simple and has clear steps to follow (Bryman, 2016).

3.2 Ethical issues

Respecting ethical standards is very essential, and many publishers have produces guidelines on ethical issues. Relevant ethical issues are;

1) Authorship, 2) Competing Interests, 3) Plagiarism, 4) Simultaneous submission, 5) Research fraud and 6) Salami slicing (Elsevier, 2019).

According to (Elsevier, 2019) the authorship is, when someone wants to add his/her name to the article, without contributing to it. A competing interest e.g. if someone is paying you to write a report with a specific outcome. Plagiarism is when one uses some other's work or information without permissions, typically copying sentences without referencing them. Simultaneous submission means, when the article you work on, you try to publish in different journals at the same time. NOVIA is using a software called "Urkund", for checking ethical issues like plagiarism.

Research fraud, is when you publish data or results, which is changed and not scientifically proven. Salami slicing is when you take major parts from one article and try to publish it as new articles.

The reason for people doing that is to increase their number of published articles. Raising harm to participants and invasion of privacy are ethical principles brought up by (Bryman, 2016).

Building up the interviews, after picking the sample, a schedule was made and the candidates were contacted. Each candidate agreed to participate in the interviews.

Doing a verbal interview and trying to document everything in the discussion is impossible, without additional tools, which is why all the interviews were recorded. Each candidate gave permission, before starting to record a session. Each interviewed candidate got a copy of her/his transcript for verification. There has not been any distribution of the recordings.

I am keeping the transcripts and recordings stored in a safe and secure place. The candidates have agreed that I published their names and some related information to them.

All the participants respected any confidentially agreement, each candidate have, with their organisation. All interlocutors will receive an electronic copy of my thesis, after it has been completed.

3.3 Encountered challenges

Conducting interviews has back sides, which can be a source of error. Such errors according to (Bryman, 2016) can be misunderstanding what is said or not said, own interpretation or missing information that was spoken. The number of interlocutors is 16, which according to Maquire (2017) is a small population and can't represent the whole population.

Making the first base plan, for my thesis project was easy, mainly due to previous and existing experience in project management. The Autonomous Maritime Operations (AMO) is a two year program ending on 31.12.2020. I normally deliver things earlier than required, which is why I contacted TRAFICOM already during the spring of 2019. There was a small issue starting in getting a supervisor from the school, as according to the AMO program plan thesis work should start in 2020 but this was sorted out smoothly.

Additionally there were some small challenges like agreeing on the interview schedule with a couple of candidates, but this was sorted out quite quickly. This was understandable as they also are occupied with their work and additional travels and sits in meetings.

Writing down the discussions and comments during the interviews was a big challenge, but therefore recording the sessions, was supporting that the quality was kept and any information was not missed. Writing the transcripts and listening to the recordings, back and forth, was very time consuming and boring. One hour of recording required approximately 4-6 hours of listening and writing a clean transcript, however doing the interviews was

interesting and brought value to the subject. I think I succeeded quite well in delivering the transcripts for verification, for most, quite soon after the interview was conducted.
This is very essential task as if the time between the interview and the writing of the transcript takes too long time, there is a risk of losing information or forgetting what one has said. Collecting and analysing the information from the transcript was more interesting than writing transcripts.

3.4 Summary

Choosing the qualitative interview method was a good choice, considering the wide network of contacts I have available. The choice of using free time and vacation to get the work done was also good as then normal work could still be conducted. The inductive approach is very straight forward and has a few clear steps to follow. The semi-structured interview worked out well as well as the discussions with the candidates, who were very open, professional and honest in their responses, giving their view and opinion on the questions. Sampling the candidates from my contact network was easy and everyone I contacted had a positive approach, to participating in the interviews. The snowball sampling added a few interesting contacts, which I originally did not have in my contact network. All the participants have a long experience from different areas in the maritime sector and were "burning" for the subject and the discussions. There were no ethical nor confidential challenges. The challenges has been writing the notes and listening to the transcripts, together with some own time issues during the autumn. Respecting ethical standards is critical and the goal should be to follow the rules, not violating the ethics standards and get a deeper knowledge on the topic one is researching.
Checking of plagiarism is in many cases done using a computer software, "Urkund" is the one used by NOVIA. (Elsevier, 2019), has a good list of ethical standards, however I would like to raise the importance of personal data handling. This need to be handled accordingly, and follow the regulations in the General Data Protection Regulation (GDPR) - Regulation (EU) 2016/679 (EUR - Lex, 2016).

4 The Empirical Study

In this chapter, I will go through the result of my interviews; each question will include information that was collected. My contact network was utilised as the sample for the interviews, using a selection of people working in the maritime sector. My supervisor, Jouni Lappalainen, gave me some additional tips on interesting persons to involve in the interview,

which I did. The interviews involved 16 participants and they represents business, education and authorities.

Chapter 4.1 will present a list of the interlocutors, their name, role and the organisation they are working for, information has been approved by all. There were five main questions used in the interviews.

Chapter 4.2 will cover question and answers from the interviews. The model for qualitative research process described by Bryman (2016), in figure 4 has been used for building up and writing the thesis.

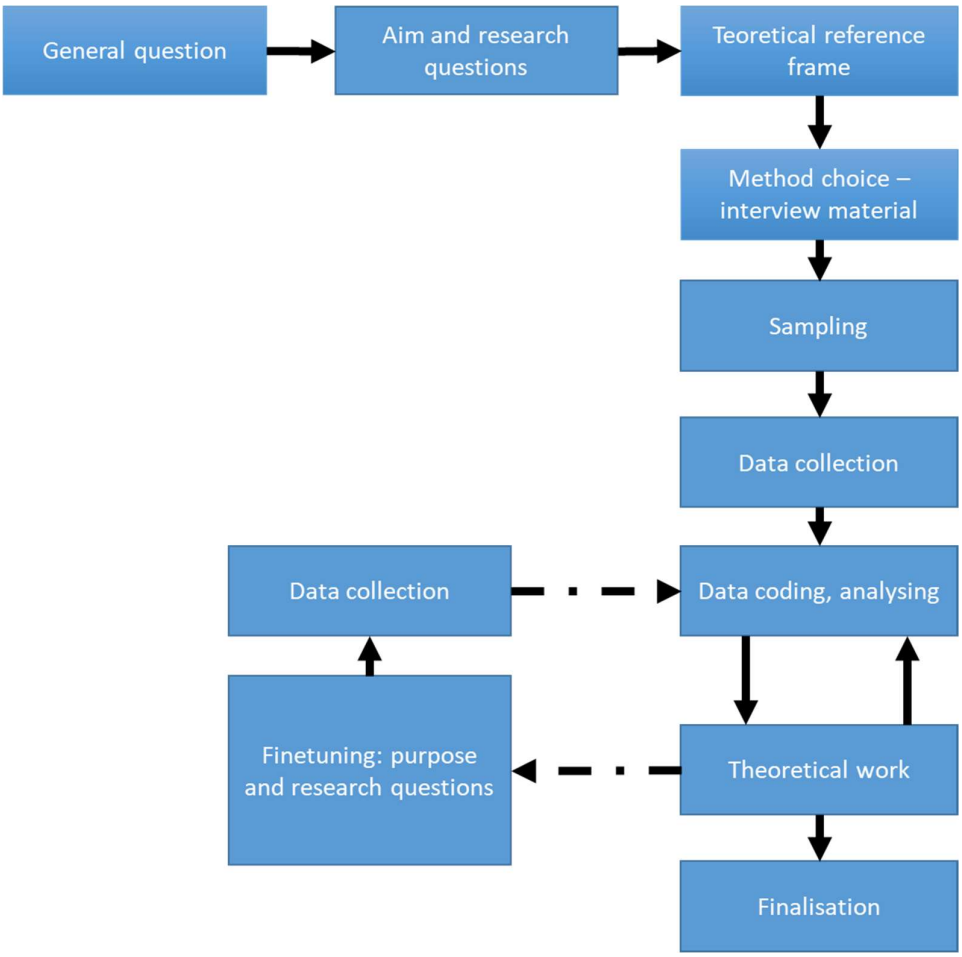

Figure 4: Adapted qualitative research process (Bryman, 2016).

4.1 Presentation of participants

All the interviewed persons are very experienced, operating in the maritime sector. Gender statistics: Female 12.5% and Male 67.5%. Permission to publish the below information has been given by each person. Interlocutors are listed in alphabetical order.

Black, Declan: Nautical Surveyor within the Irish Maritime Administration

The Marine Survey Office (MSO) is part of the Irish Maritime Administration (IMA). This is the Irish Government Department responsible for the implementation of all national and international legislation in relation to safety of shipping and the prevention of pollution of the marine environment from ship-based sources. The work of the MSO includes vessel survey, inspection and licencing; it also encompasses the oversight seafarer training and certification (www.dttas.gov.ie).

Hyyryläinen, Heikki: Director of the Maritime Safety Training Center

Meriturva is a state-owned establishment under the Finnish National Agency for Education courses accordingly (www.meriturva.fi).

Irla, Mika: Chief Program Officer

ATLAS ELEKTRONIK is the leading Naval system house in Finland providing tailored Combat and Mission Management Systems for domestic and foreign naval, coast guard and other customers and in-service support for existing systems (www.finland.atlas-elektronik.com).

Laine, Valtteri: Special Adviser, EUSBSR Policy Area Coordinator, PA Safe

The Finnish Transport and Communication Agency (TRAFICOM), is an authority in permit, licence, registration, approval, safety and security matters (www.traficom.fi).

Lappalainen, Jouni: Special Adviser, EUSBSR Policy Area Coordinator, PA Safe

The Finnish Transport and Communication Agency (TRAFICOM), is an authority in permit, licence, registration, approval, safety and security matters (www.traficom.fi).

Lilius, Johan: Professor in Embedded Systems, Head of Department at the Department of Information Technologies

Åbo Akademi University, the only Swedish-speaking University in Finland, is an internationally acknowledged research university, offering a wide range of educational options. (www.abo.fi).

Lopes, Cinthya: Dynamic Positioning (DP) lecturer

Simwave is a private maritime simulation center, established in 2018 in Rotterdam - NL, whose core business are customized courses and applied research (https://simwave.nl/).

Olli, Matti: Director, Training Services

Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets (www.wartsila.com).

Ozersky, Alexander: Deputy Director and responsible for product management and development of products related to intellectual systems

Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets (www.wartsila.com)

Ryan, Emmet: Ships Radio Surveyor within the Irish Maritime Administration
The Marine Survey Office (MSO) is part of the Irish Maritime Administration (IMA). This is the Irish Government Department responsible for the implementation of all national and international legislation in relation to safety of shipping and the prevention of pollution of the marine environment from ship-based sources. The work of the MSO includes vessel survey, inspection and licencing; it also encompasses the oversight seafarer training and certification (www.dttas.gov.ie).

Sacchi, Mauro: Director, responsible for Business Development in Marine Business
Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets (www.wartsila.com).

Ståhlberg, Peter: Managing director&Project director newbuild NLC Ferry/Wasaline
Wasaline – a small shipping company with a big heart (www.wasaline.com).

Vuorio, Micael: Head of Maritime Academy and Training Center Aboa Mare, Vice Dean Technology and Seafaring Novia UAS
Aboa Mare is a Maritime Academy and Training Center educating maritime professionals (www.aboamare.fi).

Wiberg, Anders: Senior Dynamic Position Officer (SDPO)
Solstad Offshore is a global company that is specialized in the offshore segment. We operate 136 advanced vessels worldwide, often under extreme weather conditions. We are reliable, we care about our employees and the environment (https://www.solstad.com/).

Österman, Cecilia: Senior lecturer in Maritime Science at Kalmar Maritime Academy, Linnaeus University, a state university in south-eastern Sweden (www.lnu.se).

4.2 Demographic information

The participants have many years of experience from the maritime sector. All have their office in Europe, but all of them are involved in international work, which means they work with other countries than where they have their office. Figure 5 shows the age of the participants, and the average age. There is no connection between the ages, in the figure, and the list of participants presented in chapter 4.1, ages are in random order.

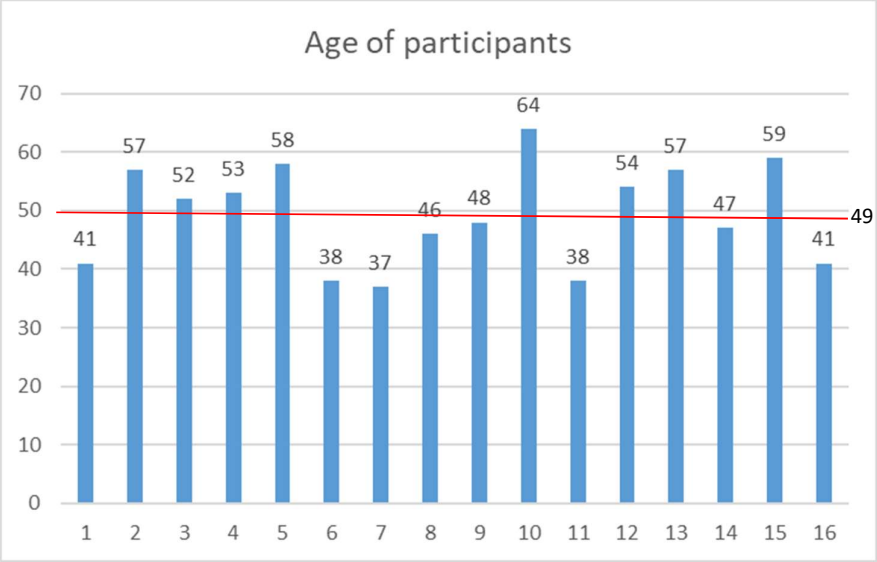

Figure 5: Interviewee's age and average age of the candidates.

Half of them, meaning 50%, of the participants exceed the average age. Assuming that the retiring age is 65 years and the starting age of work is 27 years, the participants may be visualised in table 4 as follows:

Work experience (Years)	%	Remaining working Years	%
> 20	63 %	> 10	69 %
15-20	6 %	5-10	25 %
10-15	31 %	1-5	6 %

Table 4: Working experience versus, remaining working years.

The majority, 69% of the participants have been working for more than 15 years and 31% has 10 to 15 years of working experience, assuming that their career started at the age of 27. More than half, 69% have more than 10 years of working time left, with the assumption that the retiring age is 65.

Figure 6 shows the country where each interlocutor has his/her main office. Most of them, 75% have a global responsibility, meaning that their work field is international. In this context, the definition of international is activities outside the own office country borders.

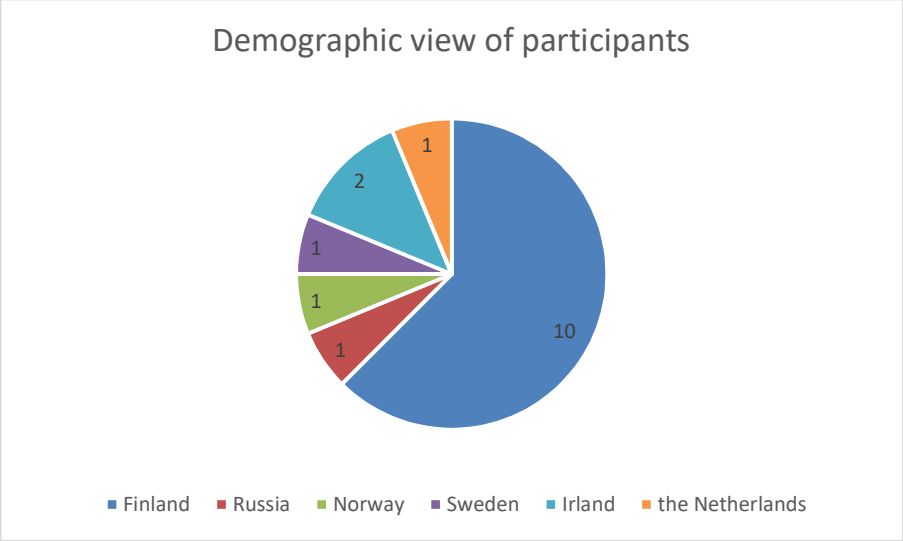

Figure 6: Geographical representation of interviewees.

Geographically 63% of the candidates are located in Finland. Categorising the candidates, according the sector they represent, and the following categories are used:

1. Business = which is defined as industry producing and selling products or services to the shipping business
2. Education = institution providing maritime courses, services or conducting maritime related research
3. Authorities = organisations which define, ratify legislation and monitor existing policies.

Seven (7) out of 16 candidates represent the business side, four (4) persons are working in education and five (5) persons works for the authorities. The representation of candidates / sector is visualised in table 5.

Sector	%
Business	44 %
Education	25 %
Authorities	31 %

Table 5: Representation of sector / candidate.

The representation from each sector is approximately spread as 0.33% / sector.

In reference to what has been stated earlier related to life-long learning it is interesting to visualise the education of the participants, figure 7 is showing the number of number of degrees / participant.

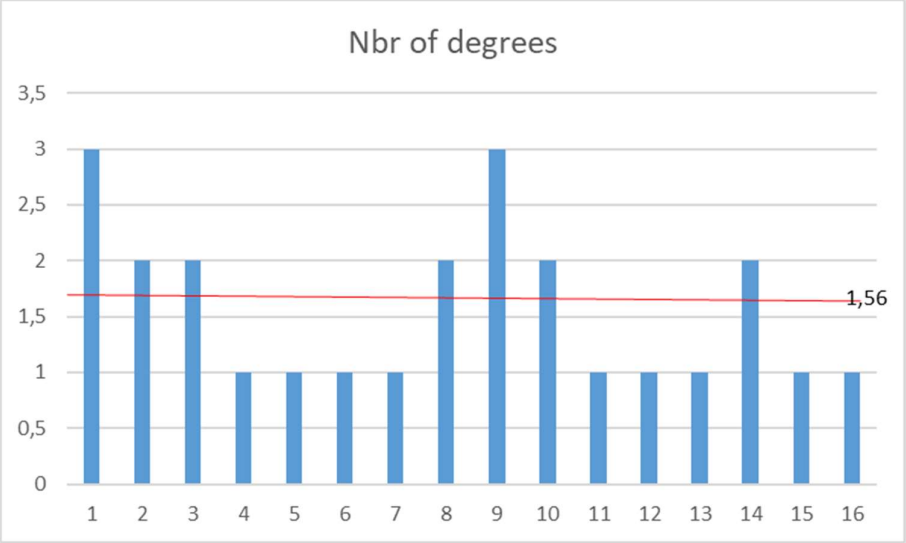

Figure 7: Number of university/applied science degrees / person.

The participants have educated themselves after their primary degree, one could call it life-long learning or continuous education. All are highly educated and 44% have two or more degrees, 13% has three degrees. This gives an average of 1.56 degrees / person. Fifty-six (56) % of the participants have a pure maritime related education, e.g. master mariner, sea engineer.

The different degrees of the participant's is shown in table 6.

Degree	Amount
Master Mariner or maritime related degrees	10
PhD or licentiate	4
Master degree or similar	8
Candidate or similar	3
Total:	25

Table 6: The participant's degrees.

Summarising all degrees will give 25 pcs, of which 10 or 40% is directly related to shipping and four or 16% has completed a licentiate or PhD degree.

4.3 The Interviews

All the interviews were scheduled and completed during 16th June and 30th August 2019. Time wise this was either vacation, weekend or evening and this approach was good, from the point that all the participants were relaxed, which reflected in the engaged and fruitful discussion with each one.

The interviews were recorded, with the permission of the interlocutors, and the clean transcript was sent to the interviewee for verification. The interview time varied from one hour up to 1.5 hours.

The discussion part of the interview was very interesting, but it was challenging to make hand notes, which is why the recordings were helping to secure the given information and missing or misunderstanding information. The recordings are stored safely and will not be distributed. Writing the transcripts and listening to the recordings, back and forth, was quite time consuming.

The upcoming chapter will be going through the questions and the replies or input from the interlocutors. The first questions (4.2.1), is about Autonomous Shipping in general, and the purpose is getting the general understanding from each participant. The second (4.2.2) question is related to structures and the need for change, as and technology are developed further. The third (4.2.3) question is about, behaviour, and whether the automation will change people's behaviour. The fourth (4.2.4) question is about education, the need for further developing the education to support the AS. The fifth (4.2.5) question is about change, and how the maritime business will need to change. All the supportive questions are listed in each chapter together with the collected information.

4.3.1 On Autonomous Shipping (AS)

Autonomous shipping is a wide definition and if not defined clearly it is used as synonym for both manned and unmanned ships and may therefore create some confusion.

Q1. What is Autonomous Shipping?

The purpose of this question, "What is Autonomous Shipping (AS)?" was to check the opinion and understanding about Autonomous Shipping, today and in the future. This question is very wide and due to the vast experience everyone has opinions from all the angles were received.

1) The definition Autonomous ships is very unclear and used as synonym for different meanings.
2) There are too many definitions already, I prefer the IMO definition: a ship which, to a varying degree, can operate independently of humans.
3) Certain segments are very suitable for Autonomous operations, e.g. inland ferries, vessels moving from point A to point B and back.

4) Certain types or segments can be achieved quite fast e.g. ferries, tug boats, cargo ships – sailing on the ocean.
5) First small vessels, within low traffic areas and geographically restricted.
6) A lot of the regulatory need to be changed.
7) National operation easier than international.
8) The technology change can't be stopped.
9) The increase of automation and digitalisation.
10) Safety to be ensured.

Specific individual comments given:

- "Shipping is a reacting business and controlled by rules, seems like the new rules are needed before something is done".
- "Jobs will disappear".

Looking at the 10 points raised, comparing it the theory in chapter 2, they very much supported actions and research done. The importance of talking the same language and having the same definitions was raised in chapter 1, where IMO has clarified the definition of autonomous in the MSC 100th session and other stakeholders like NFAS, DMA and classification societies has further developed it. This is very much aligned with comment #1. In chapter 2.3.1., where several stakeholders' points out that the regulation and legislation need to change when the new technology is implemented, but also when new business models are created like the SCC and this relates to the comment #3.

Vojković (2018) that the speed of technology devlopment and change is fast and not able to be supported by the legislation, which supports comment #5. The terminology for autonomous and remote operated ships has no yet been defined as final according to Vojković (2018).

There is a need for digitalisation as stated in EU and many other governmental organisations strategies and this supports comment #6.

The importance of safe solutions and safety first is pointed out in chapters 1 and 2 and is well in line with comment #7.

Q2. What has changed during these years of development AS?

The environment has changed and new technologies are developed and the purpose of this question is to identify how the interlocutors see how things has been changed during their work experience.

1) New technologies available.
2) Increased automation.

3) More reliable systems and better understanding.
4) Implementation is done in steps.

One person commented that "earlier IT and automation was separate, now they are integrated and the knowledge of how things work is getting thin". Another person commented: "a better formulation of the problem has been achieved" and "the technology is still too expensive compared to cheap seafarers from low salary countries".

Both Rødseth (2017) and Baldauf et al (2016) are bringing up the increased automation. Hollnagel (2012) brings out the importance of building systems as they are supposed to do and are reliable. This research support, at least partly the answer, numbered 1-4.

Q3. What will be the realization of AS and when will we have fully autonomous ships?

This question is checking the understanding of when the interviewees think that fully autonomous ships will be a reality.

1) It will take a very long time.
2) Certain segments (small vessels), within a restricted area.
3) Will need the society's acceptance.

Specific individual comments:

- "Absolutely not passenger ships, they have too many moving parts".
- "Certain types or segments can be achieved quite fast e.g. ferries, tug boats, cargo ships – sailing on the ocean".
- "Conventional ships will exist as long as we live".
- "First small vessels, within low traffic areas and geographically restricted".
- "Never".
- "Not during my lifetime".
- "I believe that the next generation has retired before all ships are autonomous".
- "Everything need to be digitalised first, the equipment is motley e.g. how reports are interpreted and calculated (e.g. emission)".
- "When you have so valuable asset (ship) or a valuable cargo the crew cost becomes minimal, even the logistics related to the crew become so minimal".

Rødseth (2017) is bringing up the importance of having more advanced ICT systems compared to conventional manned ships and that the legislation will not allow unmanned ships if there is a significant public resistance against it.

The research in chapter 2 shows that there are many other issues with legislation and regulatory, remote operation and human factor related to be solved which indicates that it can take some time. The research support the comments in point #1 and #3.

Q4. Is there any other industry that has completed more compared to shipping?

There are many industries working on automation related issues and this question is identifying such, which could be used for further research.

1) Aviation.
2) Automobile.
3) Manufacturing and Energy industry.
4) Smart Ports.
5) Military.
6) Consumer industry.
7) Trains and Railway.
8) Subway.
9) Space.
10) Process industry.
11) Mining

Aviation and Automobile are often mentioned as forerunners in automation. The aviation industry has additionally the advantage with few manufacturers which are able to keep the standardisation at a high level and a cost efficiency.

Q5. Which organisations have a key role in getting Autonomous shipping implemented?

People working within the Maritime sector know the key stakeholders very well and therefore it is no surprise looking at the list of organisations which came out from the replies.

- IMO
- United Nation
- European Commission
- Classification societies
- Governments
- Industry and commercial actors
- National authorities (e.g. TRAFICOM)
- Ship owners
- Universities and educational institutions.

Many of the above organisations is also referred to in chapters 1 and 2.

Q6. Do you think the legislation will support the development and implementation?

In many research articles, legislation and regulation issues are raised from the point that adjustments are needed for supporting autonomous ships. The purpose of this question is to collect the interlocutor's opinion on legal matters.

1) The slowness of legislation changes.
2) The legislation is always lagging behind.
3) The national legislation is easier to change then the international one.
4) The legislation needs to be adjusted to support the development of Autonomous ships.

Individual statements related to the support of legislation:

- "Attorney general Office has stated that we can't step outside the law".
- "Change of legislation need to go through Parliament".
- "The responsibility question is central to define".
- "The biggest obstacle and retardant factor is the legislation".
- "The regulatory is very unclear today".
- "Finland, Sweden, Norway and Scandinavia will move faster".
- "For the regulation it is a big dilemma for the social impact, when you want to propose something that eventually would reduce an accident, anyway improve the safety".
- "Reporting and calculations should be standardised (e.g. emission calculation)".

Core Advokatbyrå (2018) recommends that changes to the regulatory should be kept at a minimum and focus should be on updating existing rules not creating new ones. Vojkovic (2018) raises the issue that the speed of technology development and change is fast and there is a risk that the legislation will not be able to support it. "*Legislation will not allow unmanned ships if there is a significant public resistance against it. Societal risk acceptance or adversity is a complex issue and not necessarily related to the actual risk level*" (Rødseth, 2017).

4.3.2 Changing structures

This chapter will contain information regarding structures, which might need to change due to increased automation, more integrated systems and new technologies.

Structures are defined, in this context, as legislation, humans, factors, procedures, education and training, elements which might need to change due to moving into some level of autonomous, defined in chapter 1.1.

Q7. What structures need to be changed due to the realisation of AS?

1) Legislation need to change. (Also in Q6).
2) Education and training need to be restructured and changed.
3) Medical requirements need to be adjusted (Also in Q8).
4) More IT knowledge will be needed.
5) Everything will gradually change: training, classification societies, pilots, manufacturers, regulators, port operators, search and rescue, law enforcement etc.

Individual comments are:

- "Uberisation" of shipping.
- "Port must be adapted to handle Autonomous ships".
- "Ship building, no one-offs are built, should go for mass production".
- "Certification will be renewed".
- ""The way technology is developed and tested need to change".
- "The whole infrastructure needs to be developed, it is one entity".
- "Society's approval".
- "VTS need to access navigational information".
- "Simulations need to play a key role".
- "Search and Rescue procedures need to be updated".
- "Firefighting procedures need to be updated".

Rødseth (2017) is pointing out the importance of the acceptance from the society. Hynnekleiv et al (2020) identifies the importance of IT skills in the future education. According to Baldauf et al (2016) there is a need for improved IT skills due to new systems and increased automation. The need or more advanced ICT systems is brought up by Rødseth (2017) and Alop (2019) sees that ICT competences are becoming more and more important and the future teachers should not be the ones having exclusive knowledge and skills.

Q8. Is there a need for changes regarding Health/Medical requirements?

1) Health and medical requirements need to be revised.
2) Remotely operating a ship from a wheel chair should not be a hinder.
3) Mental health is still important.

Individual comments:

- “The requirements could be broadened to offer more diversity”.
- “People are healthier if they are less fatigue and stressed”.
- “On Autonomous ships the medical equipment on board need to be revised compared to today’s situation”.
- ”70+ seafarers the health of whom does not allow to work onboard, climbing stairs, but their mental health is good and they could easily work in a remote control center, passing on their knowledge to the younger people”.

Core Advokatbyrå (2018) recommends that the health and safety issue could be subject to the legislation ashore in remote operating centres. Technostress characteristics fatigue, headache and restlessness was brought up by Brod (1984). Studies has also been done by Arnetz and Wiholm (1997) and Burmeister et al (2014) identifying similar characteristics.

Q9. Does the master need to be on board?

1) “The key issue to solve is the legislation and the role and responsibility of the Master (Captain)”.

The majority answered: “Yes, that at least for the transfer period”.

- “The master will probably not be needed”.
- “Yes, absolutely”.
- “When the technology is reliable it can make predictions better and faster, can predict earlier dangerous and close by situation than human”.

This question divides the opinions of the interlocutors. COLREG rule #2 defines the responsibilities of the master and according to Core Advokatbyrå (2018) the obligations and the definition of the master needs to be clarified for the remote operator. Vojković (2018) sees the defining of the master’s role as a legal challenge. “*As a general principle, the remote operator should be considered equal to the master in the merchant shipping act and have the same rights and obligations with the amendments deriving from the nature of the issue*” (Ramboll & CORE, 2017).

4.3.3 The AS will affect behaviour

Implementing new technologies might affect our behaviour and the purpose is to collect that information from the interviewee’s opinion.

Q10. Will AS will affect people's behaviour?

1) "There are always people resist changes and people who accept them".
2) "Increased automation will change the way to behave".
3) "The communication needs to be developed".

Individual comments:

- "Today's ships are like a community, people care about their ship".
- "Caring about the ship moves to an object which is cared about".
- "A human is capable of creative thinking, a machine not".
- "Direct leading of people changes to leading teams".
- "Autonomous ships need special identification signs".
- "The touch and feel disappears".

Ramboll (2017) points out the importance of clear definitions for communication and understanding points of view. Burmeister et al (2014) suggest that a gap analysis is made, identifying gaps related to communication and information issues e.g. human – machine interaction.

Q11. How does the development effect interaction and communication?

1) "Communication need to be developed".
2) "There need to be a clear way of communicating between ship-ship, ship-shore and autonomous ship-not autonomous ship".

All agreed that the communication needs to be developed and there need to be clear strategies for communication between ship-ship, ship-shore and autonomous ship-not autonomous ship.

- "Standardised component and ways to operate must exist".
- "Seafarers need to communication in a better way, standard phrases is not used".
- "There need to be a way to identify however a ship is autonomous or not".
- "How do you react to a MOB situation if you are alone on board, does the sensors identify the situation and are they able to react?"
- "The Human-machine interaction, especially between conventional vessels and autonomous ones will be the biggest issue".
- "We already communicate with robots, without knowing about it e.g. 'Alex' and 'Siri' in mobile phones".
- "Situational awareness need to be very good".
- "Some new way of communicating or concept need to be developed".

According to Ramosa (2019) points out the importance of considering the human-system interaction and human failure. "*It is vital to understand how operators obtain and maintain SA under such a sociotechnical system and more importantly how the interfaces could impact their subsequent decision-making*" (Man, Weber, Cimbritz, Lundh, & MacKinnon, 2018).

Q12. How does this development impact stress?

1) When the technology works and is reliable, stress should not increase, the assumption is that it will decrease.

Individual statements:

- "Stress will become more rare, but also more intensive during failure times".
- "Technostress need to be dealt with".
- "Operators will phase posttraumatic stress".
- "The coming generation is used to digitalisation".
- "There are already a lot of work today done with computers".
- "In the beginning when everything is new, stress might increase".
- "Stressful if you don't have the full information or something goes wrong or you lose a sensor".

Brod (1984) defines technostress as a modern disease caused by computer technologies and effect the healthy manner of a human being. According to Raišienė et al (2013) a constant usage of technologies creates a dependency to be connected with others constantly. Burmeister et al (2014) states that for bridge operators on board ships, pointing out that some of these factors might be reduced from a risk point of view, removing the human errors, but new risks might appear when ships are remotely operated and the model operation is changed. Baldauf et al (2016) recommends that simulator exercises have the advantage that one can run complex and stressful scenarios, which will train the user how to handle safety situations in a risk free environment.

Q13. How do you see the collaboration between human and machine in AS?

Individual statements:

- "Machines rarely do silly mistakes, but humans are much better in unusual situations".
- "Systems gets more complicated and the human understanding fades away".
- "Todays the human has the power, but if AI controls how can one trust or understand the decisions and logic?"

- "The human thinks emotionally – a computer analytically".
- "The legislation need to support that machines can make decisions".
- "A machine can make mistakes if programmed wrongly".
- "How do we develop systems which are reliable enough and adaptable so we can trust them?"
- "There need to be clear commands or instructions between human and machine".
- "If the technology doesn't work there need to be a way to solve it e.g. by manual control".
- "A machine is not feeling the vibration, losing touch and feel when doing remote operating".

Q14. Can one manage / control / operate several ships at the same time?

1) One can manage several ships, when

a. The environment is closed and restricted.
b. In low traffic zones.
c. On open waters (oceans).

There was uniform agreement that one can manage several ships when a) the environment is closed and restricted, b) in low traffic zones and c) on open waters (oceans).

- "More complex area max 1 ship".
- "Remote controlled 1 ship – remote monitored several ships".
- "Depending on the surroundings like weather, wind, cargo, traffic density".
- "If you have autonomous traffic lanes"
- "Everything can be done automatically – no need for manual control".
- "Different levels and where they operate – like aviation control".

According to Porathe et al (2014) a number of operators would monitor a number of autonomous, unmanned ships and in the MUNIN project one operator would monitor six (6) vessels at the time, based on alarms and irregularities (Porathe T. et al., 2014).

Rødseth (2017) believes that the ongoing development regarding autonomous, unmanned ships will also increase the automation on manned ships and the total staffing of SCC will be less than 1, as one operator should operate several ships.

4.3.4 Perspectives on changing education

Bringing in new technologies is one important part in the shipping and might impact how we need to develop maritime education and training (MET).

Q15. What is your view opinion on future education?

1) The education and training is important, and it has to change to support the new technology and the autonomous shipping.

A common statement from the interlocutors is that education and training is important, and it has to change to support the new technology and the autonomous shipping.

- "Needs to develop the education in two lanes in the transition phase, one supporting autonomous and one supporting conventional ships"
- "The content of the training will change".
- "Remote operator do not need to be a master mariner".
- "Pilots do not work in flight control".
- "Additional education needed for understand automation systems".
- "IT will play an important role in the future".
- "Separate qualification and certificates needed for remote operators".
- "More simulation based training needed".
- "Important that we don't get stuck with old roles".
- "More understanding of complex systems".
- "Maybe learning how to use the sextant is not needed in future courses?"

Ramboll et al (2017) is recommending additional competences related to steering an autonomous ship and the equipment in use, should be added into the education and qualifications required. The Danish educational approach with the concept of a "dual officer" is a way of receiving wider knowledge with both deck and engine skills.

Q16. How will young people be attracted to education in the future?

1) Will rather do office work.
2) New technology attracts.

Individual statements:

- "I rather go to a control center or simulator than spending long times at sea"
- "Feeling is sometimes good e.g. when you open the door to the engine room and smell an oil leakage"
- "To spend more time at home with family and friends"
- "Doing office work 9 to 5".
- "I rather work at a remote operation center, than spending 3-5 months at sea".
- "No risk for seasickness working at a remote operating center".

- "Maybe marketing of the education need to be targeting some other group than today".
- "In the future we need to hire 'PlayStation' players".

The studied research do not directly bring up direct answers to this question, but Baldauf et al (2016), Rødseth (2017) and Alop (2019) points out the importance of IT knowledge.

Q17. How will future affect the education development – what kind of knowledge will be needed?

1) More IT education will be needed. (Also in Q7).

Individual comments:

- "Basic understanding of AI and Cyber Security".
- "Ability to understand processes, conditions and combinations".
- "Automation knowledge".
- "Combined education (deck officer, engine, electrician)", e.g. Electro Technician Officer (ETO).
- "Simulator training is a good concept for teaching things".
- "Still one need to understand the ships movements and how it behaves".
- "A lot of data will be available, and the ability to choose relevant data in a specific situation".
- "Multi knowledge persons needed".
- "Using computer at an early age and playing computer games will give that generation better possibilities than our".

The importance of future IT knowledge has been pointed out in Q7.

Q18. Do remote operators need sea experience?

This question divided the answers, those having an active maritime background from ships said that sea (practical) experience is a must.

- "It depends on the operations".
- "One will need practical experience during the transition period".
- "We will still educate master mariners for the conventional fleet and additional training for operators".
- "Without the touch and feel and the knowledge of the ships characteristics one might drive the ship to its limits from on operating center".

Ramboll et al (2017) is recommending that additional competences related is needed and that the operators have minimum complete training for supporting COLREG rule 2, with virtual simulator experience replacing practical seagoing experience.

Q19. What will happen with the certification and qualification in the future?

1) Qualifications and certificates will be needed in the future as well.
2) The existing renewal for certain certificates every five (5) year is ok.

All agreed that qualifications and certificates will be needed in the future as well. The existing renewal for certain certificates every five (5) year seems ok for the majority.

- "Combined education should be promoted (deck officer, engine, and electrician)."
- "The technology develops so fast that maybe yearly updates, by your own organisation would be in place".
- "This is very much a political and economic question".
- "Training will be needed, but in a different way, on systems and hardware".
- "In general we need to work more with life-long learning in all working situations".
- "Certification is one way to verify the education and knowledge".
- "Maybe in the future practical experience can be received from other industries, e.g. forest or paper industry".
- "Operator education will be needed".
- "IMO and STCW is controlling this on a detailed level".

SOLAS is requires that certificates exist and are maintained. Cefor & Core Advokatbyrå (2018) sees a clear need for education, training and certification. Ramboll (2017) thinks that the Danish model with "dual officer" will be more common. "*To cope with increasing industrial demand and accelerated technological development, the global standard of maritime training and certification will also require revision and adaption*" (Sharma, Kim, Nazir, & Chae, 2019).

4.3.5 AS's effect on the maritime business?

The ongoing and future development might bring changes to the maritime business, and this question will show the collected opinions of the interviewees.

Q20. How AS will change the maritime business?

Individual opinions:

- "Cost saving will be achieved".
- "Changes in ships design, materials".

- “Uberisation or consolidation of maritime transports”.
- “More space for cargo less for crew”.
- “Increased safety”.
- “Removing of brokers, intermediates as a lot of surveys will disappear”.
- “More risk bade approach and on-line audits and inspections”.
- “Changes in firefighting and emergency equipment and procedures”.
- “Crew will spend much more times in simulators”.
- “Jobs will be lost, but new ones will be created and roles adjusted”.

Sharma et al (2019) and Porathe (2019) raises the point that many of the manual routines will be automated in the future, and job descriptions will be changed as a result.

Q21. How will the technology change the behaviour in the future?

Individual comments on how the technology will change the behaviour:

- “There will be shift of control from ship to shore”.
- “The interaction and communication with small vessels will be a big challenge”.
- “The technology becomes faster and faster and we need to adapt”.
- “We need tools for faster adaptation to the changes”.
- “A big advantage being ashore compared to on board from a stress point of view.
- “Connecting to experts easier when working from shore”.
- “Mooring operations will be automatically”.
- “The big picture need to be approved and accepted by the society”.

Research references made in Q7, Q10, Q11, and Q16 support most of the above comments.

4.4 Summary

All the questions are supporting each other and some even overlapping looking at the answers. All of the interviewed are highly educated, with a long and wide experience from the maritime sector. The average number of degrees is 1.56 / interlocutor, which shows that life-long learning is adopted and knowledge is of interest. The representation is approximately 33% business, 33% authorities and 33% educational and the majority are working internationally, despite their home office is in a certain country.

The majority of the interlocutors said that the definitions and terminology need to be clear. The word Autonomous is quite undefined and some people use this for everything or synonymously, which might lead to misunderstanding.

Certain things came up several times in the thesis, some already addressed in the research and others might be in progress, but limited amount of public information available.

The three mostly mentioned things are:

1) Legislation and regulatory.
2) More IT knowledge is needed.
3) Education and training.

Regarding the first point, legislation and regulatory, the common understanding is that adjustment is needed and the changing of the rules moves slowly. More IT knowledge will be needed in the future is brought up by several researchers, and also in the questionnaire. There is quite few public articles on education and training need to change and they are mainly pointing out that changes are needed, but the deeper research on how is missing.

The automation will lead to jobs being lost, but new ones will be created and roles and responsibilities need to be updated.

5 Discussion

I will reflect with some personal opinions in this chapter. It is amazing how much information is available and many skilled people working in the Maritime sector, especially those who have a long experience have a good and deep knowledge about things together with a huge network.

Even if the future is difficult to forecast, it is quite clear that new technologies are being developed all the time, including more automation and integrated systems. History has shown that when big industrial companies decide to develop something it is difficult to stop, which means that the number of autonomous vessels and concepts will increase, it is more a question of the timeline.

Looking from an educational and training perspective, they need to be developed, the question is how? In my view changing the STCW related courses will be too slow, some courses might be developed towards the way of delivering them from a digitalisation and life-long learning perspective. This means that we need to think out of the box and find other creative solutions which gradually might develop into major changes to the STCW courses in a longer perspective.

NOVIA has already shown an alternative way of bringing in new education via the Master's program. The advantage with them is that course modules are not STCW related and can easily be replaced to support new things that are coming up. How to finance such programs is a thing which needs to be solved.

The Finnish approach, allowing up to 30 sea days from enough simulator exercises, I believe is a good path to follow and further develop. The argument for this is that we see that new technologies are coming up and they could be tested in the future simulators. Maybe accident scenarios could be built in the exercises and learning from them in a secured environment could reduce future risks. In general an increased use of simulators would support the technical development, assuming the simulators are developed accordingly.

5.1 Recommendations

Based on my thesis I believe there are certain improvements, which could be done, I list my recommendations by organization, but keeping in mind that many stakeholders need to work together.

Organisation	**Recommendation**
Finnish Transport and Communication Agency (TRAFICOM)	Allowing 30-60 sea days from simulator exercises.
	Defining criteria's for the above.
	Establish "Dual officer" certificate.
	Defining standard reports , e.g. emission reporting.
NOVIA University of Applied Sciences (Aboa Mare)	Further develop the Master programs and the courses.
	Increase co-operation with international maritime educational institutes.
	International research projects.
	Develop the simulator environments e.g. to include accidents.

Table 7: Future recommendations.

Funding of new programs needs to be solved and many stakeholders should be participating in such a discussion.

5.2 Future research

During this research work many interesting issues for further research has been raised. The following questions would either be a good research area for a another Master's Thesis or a Ph.D.

- How has the airplane industry managed to standardize building and what can the shipping industry learn from that?
- Is it worth to combine VTS and Master Mariner education?
- How to engage working people in the lifelong learning?
- Comparing the Master mariner studies within Scandinavian Maritime institutions?

- Will the Traffic Alert and Collision Avoidance System (TCAS) used by aviation bring added value to the autonomous shipping development?
- Can VTS be developed to operate ships remotely?
- Define methods for clear communicating, ship-ship, ship-shore, autonomous ship-not autonomous ship.
- What kind of IT knowledge will be needed in the future education and training?
- How would new model courses look like?

6 Conclusions

The Maritime Unmanned Navigation through Intelligence in Networks (MUNIN), co-founded by the European Commission and executed between 2012 and 2015, with the target to "*develop and verify a concept for an autonomous ship, which is defined as a vessel primarily guided by automated on-board decision systems but controlled by a remote operator in a shore side control station*" (MUNIN, 2016) has been an icebreaker generating a lot of other research. The Advanced Autonomous Waterborne Applications Initiative (AAWA), 2015-2017 have also been a forerunner, in generating other researchers to do articles related to autonomous and remote controlling ships (AAWA Position Paper © Rolls-Royce plc, 2016).

The technology development moves fast forward, aiming to find better ways to save costs and increase the safety, all as a part of digitalisation. Major stakeholders are all involved, the European Commission, Governments, national authorities, Ship owners, IMO, classification societies, the industry, maritime educational institutions and many more. Funding is approved from many of the stakeholders and researchers have been busy analysing the consequences and what need to be done when we are moving forward with the development of Autonomous ships. A lot of research has been done published, but still there is still much to do, especially on areas where there is limited research available, like education and training.

Research work has been done in many areas e.g. human factor, legal issues, remote operating, education, rules, safety and unmanned operations, this work will continue.

The Danish Maritime Authority (2017) published a report on "Analysis of regulatory barriers to use of Autonomous Ships", in cooperation with lawyer companies Ramboll and Core Advokatbyrå. The report is covering many issues like legislation and rules, manning, navigation, liability in a good way and it recommended reading.

Legal issues seem to be a bottleneck, and seems nationally to be easier to solve than internationally according to researchers.

This research has focused on the two research questions:

1) What is Autonomous Shipping (AS) and what are the implications for the structure?
   The research has shown that structure, like human factor, legislation, education, Qualifications will be impacted.
2) How will AS impact maritime education?
   Many researchers have pinpointed that education need to change and IT knowledge needs to be increased.

Comparing results against research will be concluded per the five main questions below.

1. What is Autonomous Shipping (AS)?- Q1-Q6

Having a clear definition for Autonomous Ships came up strongly form the interviews and this is supported by the research and IMO, NFAS and DMA, were defined different levels for clarifying the different meaning. This is also supported by Vojković (2018).

Rødseth (2017) and Baldauf et al (2016) is bringing up the increased automation, which is also brought up in the interviews. Rødseth (2017) believes that the ongoing development regarding autonomous, unmanned ships will also increase the automation on manned ships

The need for changing or adapting the legislation is pointed out in many sub questions, which is also supported by the research in chapter 2. Core Advokatbyrå (2018) recommends that changes to the regulatory should be kept to a minimum and focus should be on updating existing rules not creating new ones and Vojkovic (2018) doubts that the legislation can support the fast development of technology.

2. What structures need to be changed due to the realisation of AS? – Q7-Q9

More IT knowledge will be needed and something that was pointed out in the answers. Baldauf et al (2016) as well as Rødseth (2017) and Alop (2019) sees the need of increasing the IT skills and bringing in more IT knowledge and in education. Hynnekleiv et al (2020) identify the importance of IT skills in the future education.

Health and medical requirements need to be revised and remotely operating a ship from a wheel chair should not be an obstacle according to the interlocutors. Core Advokatbyrå (2018) recommends that health and safety issue could be subject to the legislation ashore in remote operating centres. Several studies by Arnetz and Wiholm (1997) and Burmeister et al (2014) is identifying technostress characteristics when using a device too long.

Whether a ship will need a master in the future divided the answers.

Those with a master mariner background and shipping experience did not believe that a ship can operate without a master onboard for a long time. Core Advokatbyrå (2018) and Vojković (2018) raise the importance of defining the obligations of the master for the remote operator.

3. What is your opinion on how AS will affect people's behaviour? – Q10-Q14

Increased automation will change the way to behave and the communication need to be developed according to the interviewees and there need to be a way for communicating ship-ship, ship-shore, autonomous ship-not autonomous ship. Ramboll (2017) points out the importance of clear definitions for communication and understanding points of view. Ramosa (2019) point out the importance to consider the human-system interaction and human failure.

Stress should not increase in a normal situation according to the answers, but according to Raišienė et al (2013) a constant usage of technologies create a dependency to be connected with others constantly, which could lead to technostress according to Brod (1984).

4. What is your perspective on education? – Q15 – Q19

Education and training is important, and it has to change to support the new technology and the autonomous shipping according to the answers. Ramboll et al (2017) recommends additional competences related to steering an autonomous ship and the equipment in use, should be added into the education and qualifications required. "*The Danish educational approach with the concept of a "dual officer" 94 will presumably become more common*" (Ramboll & CORE, 2017).

Participants think that new technologies and working at an office will attract young people to the maritime education. The research is not bringing up any direct answers to the statement.

More IT education will be needed according to the replies and in the future we might need to hire "Playstation" profiles. This is supported by Baldauf et al (2016), Rødseth (2017), Alop (2019) and Hynnekleiv et al (2020) pointing out the importance of IT knowledge.

According to those with a sea background remote operators will need sea experience for getting the touch and feel. Ramboll et al (2017) recommends that additional competences related are needed.

Certificates and refresher will be needed in the future as well, which is supported by Cefor & Core Advokatbyrå (2018), Ramboll (2017) and Sharma et al (2019), but revision and adaptation will be needed.

5. How will AS change the maritime business? – Q20-Q21)

According to the participants gains may come from increased safety, cost saving, changes in procedures but jobs might be lost. Auto-mooring (Ship Technology, 2019) implemented in Tallinn is an example of increasing the safety as no human need to handle the ropes.

Sharma et al (2019) and Porathe (2019) points out that many of the manual routines will be automated in the future, and job descriptions will be changed as a result.

6.1 Concluding remarks

This journey started already in April 2019, when agreeing with the Finnish Transport and Communication Agency to do my Thesis for them. Now more than one year later the work is completed. Looking into the mirror it has been an interesting both jumpy journey. The most boring was writing the transcripts as one had to listening to the recorded material several times before getting a good transcript. Interviewing people was nice and also gave me new knowledge and ideas to work on. Analysing the transcripts and finding themes and key word was interesting and partly time consuming. Reading the research required many work hours, but gave deeper knowledge in the field as well as a good understanding what is going on. The writing part required focus and time, but having a normal work parallel, this meant late evening hours and weekends. There will a lot of disruptions and times when you are not able to write, which lead to a situation that it felt like starting from the beginning after a longer writing break.

Always when one has completed something it feels great, also this time and this journey has been learning and deepening my knowledge regarding autonomous ships.

A recommendation to people starting to write their Thesis is that it is advisable to start the writing process in good time. It will take more time that you can imagine and their might be obstacles on the way changing the original time plans.

Finally I wish that this work will be of interest and bring contribution to future research work.

Bibliography

AAWA Position Paper © Rolls-Royce plc. (2016). *Autonomous Ships The next steps.* London: Advanced Autonomous Waterborne Applications (AAWA) partners. Retrieved from https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf

Aboa Mare. (n.d.). *About Us*. Retrieved 01 12, 2020, from Maritime Academy and Training Center educating maritime professionals: https://www.aboamare.fi/About-Aboa-Mare

Aboa Mare, Novia UAS. (n.d.). *Maritime Research & Development - MasterSIM*. Retrieved 01 12, 2020, from Aboa Mare Maritime Education: https://www.aboamare.fi/MasterSIM

Alop, A. (2019). The Challenges of the Digital Technology Era for Maritime Education and Training. *European Navigation Conference (ENC)* (p. 5). Warsaw, Poland: European Navigation Conference (ENC). doi:10.1109/EURONAV.2019.8714176

Baldauf, M., Dalaklis, D., & Kataria, A. (2016). Team training an safety and security via simulation: a practical dimension of maritime education and training. *INTED2016 Conference* (pp. 8519-8529). Valencia, Spain: World Maritime University. Retrieved from http://commons.wmu.se/lib_papers/2

Baldauf, M., Kitada, M., Mehdi, R., & Dalaklis, D. (2018). E-Navigation, digitalization and unmanned ships: Challenges for future maritime education and training. *Proceedings of INTED2018 Conference* (p. 6). Valencia, Spain: International Technology, Education and Development Conference (INTED). Retrieved from https://www.researchgate.net/profile/Dalaklis_Dimitrios/publication/323701325_E-Navigation_Digitalization_and_Unmanned_Ships_Challenges_for_Future_Maritime_Education_and_Training/links/5aa68e930f7e9b463804d132/E-Navigation-Digitalization-and-Unmanned-Ship

Baxter, G., & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers, 23*, 4-17. doi:doi.org/10.1016/j.intcom.2010.07.003

Belev, B. C., & Daskalov, S. (2019). Computer technologies in shipping and a new tendency in ship's officers' education and training. *IOP Conf. Series: Materials Science and Engineering. 618*, p. 8. IOP Publishing. doi:10.1088/1757-899X/618/1/012034

Brod, C. (1984). *Technostress: The Human Cost Of The Computer Revolution* (Vol. 1st edition). Addison-Wesley.

Bryman, A. (2016). *Social Research Methods* (Vol. 3). Stockholm: Liber AB.

Bureau Veritas. (2017). *Guidelines for Autonomous Shipping.* Paris, France: Bureau Veritas. Retrieved from https://www.bureauveritas.jp/news/pdf/641-NI_2017-12.pdf

Burmeister, H.-C., Bruhn, W., Rødseth, Ø. J., & Porathe, T. (2014). Autonomous Unmanned Merchant Vessel and its Contribution towards the e-Navigation Implementation: The MUNIN Perspective. *International Journal of e-Navigation and Maritime Economy, 1*, 1-13. doi:http://dx.doi.org/10.1016/j.enavi.2014.12.002

Cefor&Core Advokatbyrå. (2018). *Maritime autonomous surface ships - Zooming in on civil liability and insurance.* Aarhus, Denmark: Cefor. Retrieved from https://cefor.no/globalassets/documents/industrypolicy/news/mass---zooming-in-on-civil-liability-and-insurance---10-december-2018.pdf

Digital, Internet, Materials & Engineering Co-Creation. (2017, 01 03). *News -"Jaakonmeri on testimeri – DIMECC ja One Sea avaavat maailman ensimmäisen kaikille avoimen testialueen: Itseohjautuvien laivojen kokeilu täyteen vauhtiin*. Retrieved from ONE SEA - Autonomous Maritime Ecosystem: https://www.oneseaecosystem.net/jaakonmeri-testimeri-dimecc-ja-one-sea-avaavat-maailman-ensimmaisen-kaikille-avoimen-testialueen-itseohjautuvien-laivojen-kokeilu-tayteen-vauhtiin/

Edwards, R., & Holland, J. (2013). *What is Qualitative Interviewing?* London, United Kingdom: Bloomsbury.

Elsevier. (2019). *Ethics in Research & Publication.* Elsevier. Retrieved from https://www.elsevier.com/__data/assets/pdf_file/0012/856659/Ethics-in-Research-and-Publication-March-2019.pdf

Erdogan, O., & Demeriel, E. (2017). New Technologies in Maritime Education and Training, Turkish Experiment. *Universal Journal of Educational Research, 5(6)*, 947-952. doi:10.13.2017.050606189/ujer

EUR - Lex. (2016, 04 27). *The General Data Protection Regulation (EU) 2016/679 (GDPR).* Retrieved from Access to European Union Law: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN

European Commission. (2015, 10 09). *ECTS key features*. Retrieved from ECTS Users' Guide: https://ec.europa.eu/education/ects/users-guide/key-features_en.htm

European Commission. (2015). *Final Report Summary - MUNIN (Maritime Unmanned Navigation through Intelligence in Networks).* European Commission. Retrieved from https://cordis.europa.eu/project/id/314286/reporting

European Union. (2019, 11 18). Council Resolution on further developing the European Education Area to support future-oriented education and training systems. *Official Journal of the European Union, (2019/C 389/01)*. Retrieved from Official Journal of the European Union: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:C:2019:389:FULL&from=ES

European Union. (2019, 07 08). *Key competences for lifelong learning.* Retrieved from Publications Office of European Union: https://op.europa.eu/en/publication-detail/-/publication/297a33c8-a1f3-11e9-9d01-01aa75ed71a1/language-en

Finnish Government. (2019). *Government Programme.* Helsinki: Finnish Government. Retrieved from http://urn.fi/URN:ISBN:978-952-287-760-4

Finnish Ministry of Justice. (2013, 02 21). *Valtioneuvoston asetus aluksen miehityksestä ja laivaväen pätevyydestä*. Retrieved from Finlex: https://www.finlex.fi/fi/laki/alkup/2013/20130166

Finnish Transportation and Communication Agency. (2017, 08 16). Alusten päiväkirjat ja niihin tehtävät merkinnät (TRAFI/35849/03.04.01.00/2015). Helsinki, Finland. Retrieved from https://www.traficom.fi/sites/default/files/media/regulation/27051-Perustelumuistio_Alusten_paivakirjat_lopullinen.pdf

Fisher, D., & Muirhead, P. (2019). *Practical Teaching SKills for Maritime Instructors* (Vol. Third Edition). Malmö, Sweden: WMU Publications.

Fonsecaa, T., Lagdamia, K., & Schroder-Hinrichs, J.-U. (2019). Emergent technologies and maritime transport: challenges and opportunities. *Proceedings of the International Association of Maritime Universities (IAMU) Conference* (p. 14). Tokyo, Japan: International Association of Maritime Univiersities (IAMU). Retrieved from https://www.researchgate.net/profile/Tiago_Fonseca/publication/337947996_Emergent_technologies_and_maritime_transport_challenges_and_opportunities/links/5df77e0492851c836480edab/Emergent-technologies-and-maritime-transport-challenges-and-opportunities.pdf

Hildén, M. (2019, 10 31). Maritime Fair 2019 - Panel Discussion. *Rahikainen, Marko, Östman, Fredrik, Field, Palmia, Westerlund, Anton, Hartonen, Sirkka, Eriksson, Ronny*. Turku, Finland.

Hollnagel, E. (2012). *FRAM: The Functional Resonance Analysis Method - Modelling Complex Socio-technical Systems.* Florida, U.S.A: CRC Press.

Hult, C., Praetorius, G., & Sandberg, C. (2020). *Autonomi och Ansvar - Människans roll i framtidens sjöfart.* Kalmar, Sweden: Linnéuniversitetet.

Hynnekliev, A., Lutzhoft, M., & Earthly, J. V. (2020). TOWARDS AN ECOSYSTEM OF SKILLS IN THE FUTURE MARITIME INDUSTRY. *Human Factors, 19th – 20th February 2020* (p. 5). London, UK: The Royal Institution of Naval Architects.

International Maritime Organization (IMO. (2015). IMO Model Course 3.21 Port Facility Security Officer 2015. London, United Kingdom. Retrieved from http://www.imo.org/en/Publications/Documents/Attachments/ETB321E.pdf#search=model%20course

International Maritime Organization (IMO). (2014). *SOLAS - International Convention for the Safety of Life at Sea* (Vols. Consolidated Edition, 2014). London, United Kingdom: International Maritime Organization (IMO).

International Maritime Organization (IMO). (2017). Strategic Plan for the Organization for the six-year period 2018 to 2023. *Resolution A.1110(30)*, p. 22. London, United Kingdom: International Maritime Organization (IMO). Retrieved from http://www.imo.org/en/About/strategy/Documents/A%2030-RES.1110.pdf

International Maritime Organization. (2018, 05 25). *IMO takes first steps to address autonomous ships*. Retrieved from International Maritime Organization: http://www.imo.org/en/MediaCentre/PressBriefings/Pages/08-MSC-99-MASS-scoping.aspx

International Maritime Organization. (2018, 12 07). *Maritime Safety Committee (MSC), 100th session, 3-7 December 2018*. Retrieved from International Maritime Organization: http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-100th-session.aspx

International Maritime Organization. (2019, 11 11). *Introduction to IMO*. Retrieved from International Maritime Organization: http://www.imo.org/en/About/Pages/Default.aspx

International Maritime Organization. (n.d.). *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)*. Retrieved from International Maritime Organization: http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx

International Martitime Organization. (2017, 06 16). *Maritime Safety Committee (MSC), 98th session, 7-16 June 2017*. Retrieved from International Martitime Organization: http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-98th-session.aspx

International Martitime Organization. (2018, 05 25). *Maritime Safety Committee (MSC), 99th session 16-25 May 2018*. Retrieved from International Martitime Organization: http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-99th-session.aspx

Komianos, A. (2018, 06). The Autonomous Shipping Era. Operational, Regulatory, and Quality Challenges. *the International Journal on Marine Navigation and safety of Sea Transportation, 12*, 335-348. doi:10.12716/1001.12.02.15

Maguire, M., & Delahunt, B. (2017). Doing a Thematic Analysis: A Practical, Step-by-Step - Guide for Learning and Teaching Scholars. *All Ireland Journal of teaching and Learning in Higher Education, 3*, 14. Retrieved from https://ojs.aishe.org/index.php/aishe-j/article/viewFile/335/553

Man, Y., Weber, R., Cimbritz, J., Lundh, M., & MacKinnon, S. N. (2018). Human factor issues during remote ship monitoring tasks: An ecological lesson for system design in a distributed context. *International Journal of Industrial Ergonomics, 68*, Elsevier. doi:https://doi.org/10.1016/j.ergon.2018.08.005

Manuel, M. E., & Baumler, R. (2020). *The Evolution of Seafarer Education and Training in International Law. In Maritime Law in Motion.* Springer.

Mark, E. (2009). *Livslångt lärande ur bildningsperspektiv som strategi för högskolan.* Göteborg: Grundtviginstitutet vid Göteborgs universitet rapport nr 7. Retrieved from https://ipkl.gu.se/digitalAssets/1277/1277093_rapport7.pdf

MUNIN. (2016). *Welcome to the MUNIN Project web page*. Retrieved from Welcome to the MUNIN Project web page: http://www.unmanned-ship.org/munin/

Norwegian Forum for Autonomous Ships (NFAS). (2017). *Definitions for Autonomous Merchant Ships.* Trondheim, Norway: Norwegian Forum for Autonomous Ships (NFAS). Retrieved from nfas.autonomous-ships.org

NOVIA University of Applied Sciences. (n.d.). *Master degree programmes*. Retrieved 01 15, 2020, from NOVIA University of Applied Sciences: https://www.novia.fi/studies/master-degree-programmes

NOVIA, University of Applied Sciences. (2019, 09 12). *Master of Engineering, Autonomous Maritime Operations*. Retrieved from Matser Degree Programmes: https://www.novia.fi/studies/master-degree-programmes/master-of-engineering-autonomous-maritime-operations/

Porathe, T. (2014). Remote Monitoring and Control of Unmanned Vessels – The MUNIN Shore Control Centre. In V. Bertram (Ed.), *Proceedings of the 13th International Conference on Computer Applications and Information Technology in the Maritime*, (p. 8). Redworth, United Kingdom. Retrieved from http://publications.lib.chalmers.se/records/fulltext/198197/local_198197.pdf

Porathe, T., Prison, J., & Man, Y. (2014). Situation awareness in remote control centres for unmanned ships. *Human Factors in Ship Design & Operation* (p. 9). London, United Kingdom: The Royal Institution of Naval Architects. Retrieved from http://publications.lib.chalmers.se/records/fulltext/194797/local_194797.pdf

Raišienė, A. G., & Jonušauskas, S. (2013). Silent issues of ICT era: Impact of tehcno-stress to the work and life balance of employees. *ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES, 1(2)*, 108–115. doi:10.9770/jesi.2013.1.2(5)

Ramboll, & CORE. (2017). *Analysis of regulatory barriers to the use of autonomous ships.* Copenhagen, Denmark: Danish Maritime Authority. Retrieved from https://www.dma.dk/Documents/Publikationer/Analysis%20of%20Regulatory%20Barriers%20to%20the%20Use%20of%20Autonomous%20Ships.pdf

Ramosa, M. A., Utnea, I. B., & Mosleh, A. (2019). Collision avoidance on maritime autonomous surface ships: Operators' tasks and human failure events. *Safety Science, 116*, 33–44. doi:https://doi.org/10.1016/j.ssci.2019.02.038

Rødseth, Ø. J. (2017). From concept to reality: Unmanned merchant ship research in Norway. *2017 IEEE Underwater Technology (UT).* doi:10.1109/UT.2017.7890328

Safety4sea. (2019). *STCW Convention at a glance*. Retrieved from SAFETY4SEA: https://safety4sea.com/cm-stcw-convention-at-a-glance/

Sea Traffic Management. (2019). *STM-Validation-Final-report.* STM Publications . Retrieved from https://s3-eu-west-1.amazonaws.com/stm-stmvalidation/uploads/20190709125520/STM-Validation-Final-report.pdf

Sharma, A., Kim, T., Nazir, S., & Chae, C. (2019). Catching up with time? Examining the STCW competence framework for autonomous shipping. *Ergoship 2019*, (p. 7). Haugesund, Norway. Retrieved from https://www.researchgate.net/publication/336649453

Ship Technology. (2019, 07 26). *Automated mooring system to be installed at Tallinn port*. Retrieved from Ship Technology: https://www.ship-technology.com/news/mooring-systems-port-of-tallinn/

Studyportal Masters. (n.d.). *All You Need to Know about the European Credit System ECTS*. Retrieved from https://www.mastersportal.com/articles/388/all-you-need-to-know-about-the-european-credit-system-ects.html

The Finnish Government. (2014, 03 12). *Finland's maritime strategy 2014–2022.* Retrieved from Ministry of Transport and Communications / Publications: http://urn.fi/URN:ISBN:978-952-243-388-6

The Finnish Innovation Fund Sitra. (2019). *TOWARDS LIFELONG LEARNING.* Helsinki: SITRA. Retrieved from https://www.sitra.fi/en/publications/towards-lifelong-learning/

Vojković, G., & Milenković, M. (2018). Autonomous ships and legal authorities of the ship master. *Case Studies on Transport Policy*. doi:https://doi.org/10.1016/j.cstp.2019.12.001

World Maritime News. (2017, 12 07). *Norway Opens New Test Area for Autonomous Ships*. Retrieved from World Maritime News: https://worldmaritimenews.com/archives/237297/norway-opens-new-test-area-for-autonomous-ships/

World Maritime University. (2019). *"Transport 2040: Automation, Technology, Employment - The Future of Work.* Malmö, Sweden: World Maritime University (WMU). doi:http://dx.doi.org/10.21677/itf.20190104

Yrkeshögskolan NOVIA. (2020, 01 08). *Novia inleder sjöingenjörsutbildningen Bachelor of Engineering, Maritime Technology i Åbo*. Retrieved from Pressmeddelanden: https://www.novia.fi/om-oss/pressrum/pressmeddelanden/novia-inleder-sjoingenjorsutbildningen-bachelor-of-engineering-maritime-technology-i-abo

LIST OF FIGURES

TERMINOLOGY AND DEFINITIONS

INTERVIEW QUESTIONS