LEGAL CHALLENGES OF UNMANNED SHIPS

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"JURIDISKE UDFORDRINGER VED UBEMANDEDE SKIBE"

by

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ABSTRACT

This thesis identifies and analyses the legal challenges that will arise in the operation of unmanned ships.

First, different international and national legislation is analysed in order to find possible legal challenges to unmanned shipping. Based on the discrepancies identified, a questionnaire survey serves to consolidate opinions of Captains from a handful of selected Danish shipping companies.
In addition, the legal challenges are investigated based on e-mail interview correspondence with numerous highly acknowledged professionals within the maritime industry, including professors, lawyers, insurers, flag state and classification society representatives, as well as members of ministerial agencies and NGOs.

This thesis finds that clear legal definitions are needed to unequivocally determine the legal eligibility of unmanned ship operations, and that unmanned shipping will find several legal challenges exactly because most current international maritime conventions do not unambiguously allow for such operation.

Further legal challenges for unmanned ship operation are found in the process of securing insurance from underwriters, who at present are cautious due to the lack of approval of unmanned shipping from flag state administrations and classification societies.

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1. INTRODUCTION

The Norse god Odin had at his side two ravens, Hugin and Munin. Every morning they would fly out into the world, and return in the evening to Odin to report what they had seen. So far, this story has just been a part of Scandinavian folklore, but here at the start of the autonomous revolution, it has gained a new meaning.

MUNIN[1] is with *AAWA*[2] the two main research projects concerned with the presentation of an approved unmanned ship concept. They each highlight several of the challenges that must be overcome before unmanned shipping can be realised. Until now, the projects focus primarily on technological solutions, while the legal challenges are positioned more in the background.

Autonomous technology is evolving faster than anyone had imagined. As the attention is directed towards these technologies across numerous industries, the actuality seems greater than ever before. The maritime industry is no exception. It is therefore highly applicable to investigate:

What legal challenges arise from the operation of unmanned ships?

2. THESIS SECTIONS

The current applicable law for ships has been written way before one had unmanned ship transportation in mind. This leads to a legal interest in whether unmanned ships can comply with the law, or whether it will be necessary to renew, possibly tailor, legislation for unmanned ships.

As the crew is attempted to be removed from the ships, the question of their value in regards to the operation of the ships themselves arises. In addition, the role of the master is also transferred ashore, which intuitively will give rise to questions about his current and possible future roles, responsibilities and duties.

[1] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN final brochure , 2016)
[2] Remote and Autonomous Ships (AAWA, 2016)

Thereto a question arises on how potential marine underwriters will respond to such a relocation, possibly disappearance, of the crew and master, and how this will affect insurance interests in the unmanned ships.

The objective of this thesis is thus to examine and discuss what legal challenges an unmanned ship will encounter in relation to its operation.

3. Thesis Question

What legal challenges arise from the operation of unmanned cargo ships?

4. Scope of Thesis

The following thesis is delimitated to concern general legal challenges in the operation of unmanned cargo ships. Therefore, the authors have not as far as possible assessed the technical capabilities of future unmanned systems, nor is any financial or organisational challenges considered.

The thesis is concerned with the following conventions, which will affect the operation of the ship directly:

1. UNCLOS
2. SOLAS
3. MARPOL
4. STCW (with reference to the Danish Order on Watchkeeping, *Vagtholdsbekendtgørelsen*)

Additionally, the following legislation is included also, which via an insurance aspect indirectly will affect the operation of the ships:

1. The Marine Insurance Act
2. The Danish Marine Insurance Convention (*Dansk Søforsikrings-konvention)*
3. The Danish Merchant Shipping Act (*Søloven*)

The analysis of the law has exclusively been focusing on elements which are referring to the ship´s manning.

The thesis does not investigate cargo or type specific requirements for the ships, their crews or their operation, but general legal challenges solely.

5. Division of Labour

Both authors are responsible for all sections of this thesis.

6. Method

6.1 Pentagon

The thesis uses the pentagon from the Danish book *Den Gode Opgave*, to ensure that all the necessary elements for academic writing are included.[3] These elements are as follows:

6.1.1 The Thesis Question

What legal challenges arise from the operation of unmanned ships?

6.1.2 The Purpose of This Thesis

By answering the Thesis Question the authors seek to clarify possible legal challenges to unmanned ship transportation, which seems more relevant than ever.

6.1.3 The Empiricism of This Thesis

This thesis has used different "source types"; both primary and secondary data as described in abovementioned book.

Primary empirical data used in the thesis:

- E-mail correspondence/interview
- Questionnaire

Secondary empirical data used in the thesis:

- Webpages of organisations and authorities
- International conventions

[3] Den Gode Opgave (Rienecker & Jørgensen, 2012) s. 30-31

- National legislation
- Lloyd's Rulefinder 9.26 July 2016
- Research Reports
- Prognoses

6.1.4 The Research Tools of This Thesis

The collecting of the primary empirical data of the thesis is based on research interviews conducted via e-mail as well as a questionnaire.

6.1.5 The Methodology of This Thesis

First, selected legislation will be analysed in order to find possible legal challenges for unmanned ships, which will form the basis of a discussion. Herein, the primary empirical data collected from practising masters, via a questionnaire, and professionals, via e-mail interview correspondences, will be included to discuss the validity and extent of the challenges identified. The discussion will result in a conclusion which will declare the main legal challenges of unmanned ship operation.

6.2 Retrieval of Information

This thesis has from the very beginning used an information retrieval log to keep track of search words used. This provides a good overview of the search pattern, as recommended in the Danish book *Informationssøgning til bachelorprojektet for professionsbachelorer* by *Trine Toft*.[4]

In the initial stage, Google and Google Scholar were used for the wide-ranging retrieval, with both Danish and English keywords. Different words and combinations were used to obtain the desired wide-ranging retrieval of information. The retrieval has evolved throughout this thesis, depending on the information and hints we received from our research stakeholders, which has optimised the retrieval generally.

E-mail has been the most used method of retrieving information as our thesis involves research stakeholders from around the world. The authors have been open to

[4] Informationssøgning til bachelorprojektet for proffesionsbachelorer. (Toft, 2012) s. 24

receive empirical data from our research stakeholders as they hold knowledge about novel and ongoing research projects within the scope of this thesis.

6.3 Research Stakeholders

The authors of this thesis have been heavily relying on the opinions of and collaboration with our research stakeholders to assess the place of our thesis within the current research landscape. Concurrently, the research stakeholders have also facilitated contact with other research stakeholders, whom the authors had not previously been familiar with. Thus, the list of research stakeholders has been growing vast as the thesis has developed. Some research stakeholders have functioned as direct sources of information with useful statements, while others have had a more indirect function, sparring ideas and introducing other research stakeholders. The following research stakeholders have been used directly for retrieving empiricism:

6.3.1 Andrew Bardot

Mr. Bardot is *Executive Officer* for *The International Group of P&I Clubs*, where he, amongst other things, represents the Club on inter-industrial, public and intergovernmental levels. *Mr. Bardot* also has over 25 years of experience as a practising maritime lawyer and is former *Senior Partner* of the law firm *Bentleys, Stokes and Lowless*.

6.3.2 Phillip Belcher

Dr. Belcher is *Marine Director* in *INTERTANKO*. Previously, *Dr. Belcher* worked for the *Bahamas Maritime Authority*, and was then the Bahamas representative at meetings in the *IMO*[5].

6.3.3 Tilo Berger

Mr. Berger is *Head of ISM/ILO Department*, *Ship Safety Division* in *BG Verkehr* (German Flag State Administration).

[5] International Maritime Organisation

6.3.4 Volker Bertram

Dr. Ing. Bertram is extraordinary professor at *University of Stellenbosch*, senior lecturer at *Hamburg Universitet* as well as guest lecturer at *IMO World Maritime University*. In addition, he is *Senior Projekt Manager* at *DNV-GL*, where he arranges conferences regarding the maritime technological future. He is also author of several different publications about maritime technology.

6.3.5 Morten Bjerregaard

Mr. Bjerregaard is *Technical Manager and Claims Executive* at the P&I Club *Skuld*. In addition, he is occasionally guest lecturer at *Svendborg International Maritime Academy (SIMAC)*.

6.3.6 DNV-GL

DNV-GL (*Det Norske Veritas* & *Germanischer Lloyd*) is one of the world´s biggest classification societies, with six different *divisions*, in which this thesis has been in contact with *DNV-GL Maritime*.

6.3.7 Helle Hammer

Ms. Hammer is managing director in *Cefor: The Nordic Association of Marine Insurers*, from where she is a member of *Det Norske Veritas' Council (DNV Council)*, as well as committees at *Bureau Veritas*, *ABS*, *RINA* & *DNV-GL*. In addition, she is a board member of the Norwegian *Maritimt Forum*, chair for the *International Union of Marine Insurers' Political Forum* and member of *Representantskabet* in *Norges Bank* (The Bank of Norway).

6.3.8 Jonathan Hare

Mr. Hare is *Senior Vice President*, *General Counsel* at the P&I club *Skuld*.

6.3.9 Øssur J. Hilduberg

Mr. Hilduberg is head of the Danish Maritime Accident Investigation Board. In addition, *Mr. Hilduberg* is occasionally guest lecturer at *Svendborg International Maritime Academy (SIMAC)*.

6.3.10 Henning Jessen

Dr. Jur. Jessen is associate professor at *IMO World Maritime University*. Previously, *Dr. Jur. Jessen* has, apart from lecturing elsewhere, worked as a trade lawyer at the German Ministry for *Economic Cooperation and Development (BMZ)*.

6.3.11 Henrik M. Ringbom

Dr. Jur. Ringbom is professor at *Nordiske Institutt for Sjørett (Scandinavian Institute for Maritime Law)*. Also, he is docent at *Åbo Akademi*, and has in addition published several scientific articles within maritime, environmental and international law. *Dr. Ringbom* is a part of the *Comité Maritime International* workgroup on *Maritime Law for Unmanned Craft*, as well as a part of *Oslo Law of The Sea Forum (OSLOS)*. Furthermore, he has assisted *Advanced Autonomous Waterborne Applications (AAWA)*, led by *Rolls-Royce*, in their work on the concept of unmanned shipping in the whitepaper *Remote and Autonomous Ships, The next steps*. Moreover, *Dr. Ringbom* is the president of *The Finish Maritime Law Association* and has formerly been *Head of Department* at *European Maritime Safety Agency (EMSA)*.

6.3.12 Frank Stevens

Dr. Jur. Stevens is senior partner at *Roosendaal Keyzer Advocaten*, where he practises international transport and trade law within maritime shipping, and sits as vice president in *The Belgian Maritime Law Association*. In addition, *Dr. Stevens* is lecturer at *Erasmus University Rotterdam* and has published several articles and books on transport and trade law.

6.4 Questionnaire to Masters

The questionnaire was created with both quantitative and qualitative questions in line with the recommendations from the Danish book *"Den Gode Opgave"*[6]. The quantitative questions were designed as closed, precise questions, used to visualize a statistical picture of the master´s positions. The qualitative questions had an open formulation for the masters to exemplify a more detailed description of their positions on the question topics. Their practical experience on board will be used to

[6] Den Gode Opgave (Rienecker & Jørgensen, 2012) s. 208

inspect whether there is overlap between their comments, our analysis of the major international conventions and the responses of the research stakeholders.

As a starting point, the Thesis Question originally concerned the tanker ship segment only, by which a higher percentage of tanker masters are to be found in the questionnaire responses. Along the way however, the authors chose, for various reasons, to change the ship segment to all types of cargo ships. Thus, the authors might have been more outreaching towards tanker companies compared to other ship companies, and the responses in the questionnaire illustrate this incongruity.

6.4.1 Questionnaire With The Option of Answering Neutrally.

In an article by *Geert A. Nielsen* and *Karen Schmedes* it is written that: *"Accept af ved ikke-svar øger mange gange chancen for at få ærlige svar"*[7] *(Accept of "Don´t Know" replies increases the chance of getting honest answers in most cases).* Therefore, the authors chose to include *"Do Not Know"* as an answer option to some of the questions in the questionnaire. By doing so, the respondents will not be forced to take a position on an issue on which they do not have any.

6.4.2 Respondents

The questionnaire was sent to 230 masters on different types of cargo ships in the following shipping companies: *Maersk Line*[8], *DS Norden*[9], *Stena Weco*[10], *Nordic Tankers, Herning shipping*[11] and *Uni-Tankers*[12].

We have chosen a representative group by choosing different shipping companies of different sizes and ship types, although considering the above-mentioned incongruity. The masters have received the questionnaire via e-mail, and few directly on the social platfrom *Facebook*. The respondents had the opportunity to respond directly to the e-mail, the address specified in our questionnaire file, or by filling out an identical questionnaire online at *Google Forms*. One of the masters from *Maersk*

[7] Ledetråde til design og brug af spørgeskemaer (Nielsen & Schmedes, 2009) s. 5
[8] Maersk Line: 93 masters
[9] DS Norden: 36 masters
[10] Stena Weco: 52 masters
[11] Nordic Tankers & Herning Shipping: 32 masters
[12] Uni-Tankers: 17 masters

Line offered to share our questionnaire in the *Facebook* group *Maersk Line Captains*[13], by which the members of said group had the questionnaire available. The answers received directly on e-mail were then entered into *Google Forms* to ensure the anonymity of the respondents as well as to use the option of creating illustrative figures from the answers.

6.4.3 Pilot test

To create a questionnaire of a certain quality, we chose to have it reviewed in a pilot group, consisting of three masters and three of our classmates. Feedback was given on sentence formulation, text font, possible ambiguity, setup as well as the amount of questions. The feedback resulted in smaller corrections to the questionnaire before it was sent to the respondents formally.

6.5 Interview

As we touch upon an universal jurisdictional thesis question, it is implied that the majority of our research stakeholders are employed internationally and thus contacted via e-mail. As we initially knew the high academic and professional level of our research stakeholders, we have contacted many different possible research stakeholders to take into account the possibility of unanswered requests. The e-mail interviews have resulted in shorter, slower dialogues compared to physical interviews, which comes to show in the empiricism gathered therefrom. In contrast, the slower dialogue might provide more thoughtful and reflective answers.[14] One of the strengths of e-mail interview is the option for the research stakeholders to answer whenever they have time and inclination within the person´s own zone of comfort. This can be a weakness also, as some of our answers have been received too late to be processed in this research thesis. In addition, we have used the method of e-mail interview to conduct parallel interviews, where several research stakeholders comment on the statements of each other simultaneously.

[13] Maersk Line Captains Facebook Group consisting of 131 members of which 93 had seen the post
[14] Lokman, I. Meho: E-Mail Interviewing in Qualitative Research: A Methodological Discussion, JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE AND TECHNOLOGY—, 2006: http://staff.aub.edu.lb/~lmeho/meho-email-interviewing.pdf (besøgt d. 19.03.2017) s. 1290

7. THE UNMANNED SHIP

The following sections will describe what is meant with an unmanned ship in this thesis, so that it will be easier for the reader to understand the analysis, discussion and conclusion of the thesis.

Our thesis is based on two research projects, which are both concerned with unmanned ships. The first of such, *Advanced Autonomous Waterborne Application (AAWA)*[15], led by *Rolls Royce*, is supported by, among others, the Finnish government and has included several universities, ship designers, equipment manufacturers and classification societies. Altogether, they illuminate the economical, social, jurisdictional, legal and technological factors, to clarify the challenges that must be solved in order to make autonomous shipping a reality.

The other project, *Maritime Unmanned Navigation through intelligence in Networks (MUNIN)*[16], has support from, among others, the *EU-Commission*. The focus of *MUNIN* is to develop an approved concept of an unmanned ship. The difference lies in whereas *MUNIN* places its focus on a partly autonomous and partly remote controlled concept, *AAWA* does not takes this into account. Furthermore, *MUNIN* is ship type specific in contrast to *AAWA´s* general observations.

The two projects mention concepts as *remote control* and *autonomy*. It is therefore crucial to clearly outline the meaning of these two concepts, as it is of great significance towards the approach to the challenges faced by the unmanned ships.

The *MUNIN* project focuses on the ship being 100% autonomous from pilot station to pilot station, supported by a shore-based control center, which is continuously manned by an operator who monitors several ships at a time.[17] At any stage, the operator responsible for the ship and its obligations can take the remote-control of the ship and steer it manually.

[15] Remote and Autonomous Ships (AAWA, 2016)
[16] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN final brochure, 2016)
[17] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN final brochure, 2016)

In continuation, *MUNIN* has six operational levels[18]:

1. Autonomous execution	The operation is fully executed by the system on board.
2. Autonomous control	The autonomous execution is interrupted by autonomous problem-solving if the ship is on collision course with another etc.
3. Indirect control	The operator updates the voyage plan, which the autonomous system follows.
4. Direct control	The autonomous system solely maintains course and avoids collision.
5. Remote control	The operator has full manual control over the ship, remotely.
6. Fail-to-Safe	If the communication between the shore-based control center and the ship breaks down, the ship will activate the *fail-to-safe* mode and station itself on a fixed position.

Figur 1

Likewise, the *AAWA* project mentions *"levels of autonomy (LOA)"*[19] with many commonalities to the *MUNIN* project. *AAWA* describes *LOA* from a scale of ten levels:

[18] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN Quantitive Assessment, 2015) s. 79
[19] Remote and Autonomous Ships (AAWA, 2016)

Level	Description
10	The computer does everything autonomously, ignores human.
9	The computer informes human only if it (the computer) decides so.
8	The computer informes human only if asked.
7	The computer executes automatically, when necessary informing human.
6	The computer allows human a restricted time to veto before automatic execution.
5	The computer executes the suggested action if human approves.
4	The computer suggest single alternative.
3	The computer narrows alternatives down to a few.
2	The computer offers a complete set of decision alternatives.
1	The computer offers no assistance, human in charge of all decisions and actions.

Figur 2[20]

This scale has a great influence on, how one legally sees the ship. A ship which is unmanned can easily be under the control of a remote operator i.e. remotely *"manned"*, whilst a fully autonomous ship exclusively navigates by algorithms even if manned. *AAWA* also describes a safety system called *"fallback strategy"*[21], which actives if an error is found in the autonomous system, to ensure the safety of the ship and the environment.

To summarise, it is important to note that an unmanned ship comes in two main varieties:

- *Autonomous unmanned ships*
- *Remote-controlled unmanned ships.*

Jurisdictionally, the difference will primarily lie in whether the ship is ordered (remote-controlled) or handles situations itself (autonomous). The two main research projects have positioned themselves somewhere in-between these two stages, as the

[20] Remote and Autonomous Ships (AAWA, 2016) s. 7
[21] Remote and Autonomous Ships (AAWA, 2016)

shore-based operator can switch between having the ship autonomous or remote-controlled incessantly given by the different levels of autonomy described.

8. The Unmanned Ship and the Legislation

The following section will analyse current international conventions, and provide an idea whether these will continue to be complied with by an unmanned ship or not. The analysis will address the four biggest international maritime conventions; *UNCLOS*, *SOLAS*, *MARPOL*, *STCW* and thereafter study underlying codes such as *ISM* and *ISPS*.

First and foremost, one is to assess if the conventions apply to unmanned ships at all. It turns out that the definition of *vessel* or *ship* varies significantly from one convention to another. This is primarily because the term is defined by the function which the *vessel* or *ship* has in the given convention. *Van Hooydonk* arrives at the conclusion that the term in its essential definition does not require that a crew or a master are to be on board. [22] Other conventions do not even give a definition of the terms. One must thus expect that the terms in the current conventions will include an unmanned ship, by which such ship in principle in bound to comply with the conventions.

8.1 UNCLOS[23]

The flag state is required to ensure that any ship flying its flag is under the responsibility of a master and officers, who possess appropriate qualifications for their positions, as well as a crew likewise appropriate in qualification and size for the ship in question.[24] Nothing in this paragraph does however require that such master, officers or crew must be on board. That is, not if the flag state has considered all

[22] The law of unmanned merchant shipping – an exploration (Hooydonk, 2014) s. 407
[23] United Nations Law of the Sea
[24] UNCLOS, Artikel 94 (4)

necessary measures in regards to administrative, technological and social affairs as well as safety at sea, as the paragraph dictates.[25]

8.2 SOLAS[26]

The main purpose of *SOLAS* is to specify the minimum requirements to the construction, equipment and operation of a ship to the extent that the safety at sea is guaranteed.[27]

Regarding firefighting equipment and arrangements on board, the crew shall be trained and familiar with the ship´s arrangements and firefighting systems/equipment[28]. In addition, the firefighting ability of the ship shall be evaluated regularly by conducting training and drills onboards, which are to identify areas for improvement as well as to ensure that firefighting competencies and the operational preparedness are upheld. The requirement of training and familiarisation of a crew on board would seem outdated, as there will no longer be a crew on board. In its simplicity, the purpose of the regulation is to make sure that the firefighting ability of the ship is maintained or even continually improved. The crew requirement is to ensure this, but that does not necessarily mean that it cannot be ensured without.

Thereto, it is to be noted that it later says that the fire safety designs and arrangements *"… may deviate from the prescriptive requirements…"*[29], provided that these deviating designs and arrangements meets the objectives and the operational requirements to the fire safety of the ship. An unmanned ship could possibly be considered as having deviating arrangement, by which it not necessarily must comply with former requirement as long as the fire safety on board is not neglected or impaired hereby.

[25] UNCLOS, Artikel 94 (2)
[26] International Convention for the Safety of Life at Sea, 1974
[27] SOLAS, 1974. http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx IMO website, visited: 20.02.2017
[28] SOLAS, Chapter II-2, Regulation 15 (2.2)
[29] SOLAS, Chapter 2-2, Regulation 17

As regards the safety equipment and arrangements of the ship[30], one must first and foremost evaluate the extent to which a ship without a crew will have to comply with such regulations. In addition, it is also stated that the safety equipment and associated arrangements may deviate from the requirements provided that they – as was the case for the above regulations on fire safety also – fulfil the intended requirements and thus provide a corresponding level of safety on board.[31] By removing the on board crew, a completely new framework will arise from which the level of safety is to be determined, and one must therefore highly expect that unmanned ships will fall under this regulation until further more specific regulations have been implemented.

Concerning radiocommunication, it is required that any ship, when at sea, must maintain a continuous radio watch on appropriate frequencies.[32] It does however not state anywhere that such radio watch is to be kept on board the vessel. Whether a radio watch can be kept elsewhere practically is up for later discussion.

Looking at the safety of navigation of unmanned ships, it is first and foremost interesting to look at what requirements *SOLAS* established to the on-board manning of ships precisely. The chapter requires the flag states to establish an appropriate minimum safe manning and issue a certificate to the ship in question stating this exact manning level.[33] In addition, the minimum safe manning is to be determined taking into consideration the ship´s ability to perform a number of different operations as listed.[34] The main two things that strikes the eye from this principle of

[30] SOLAS, Chapter 3
[31] SOLAS, Chapter 3, Regulation 38
[32] SOLAS, Chapter 4, Regulation 12
[33] SOLAS, Chapter 5, Regulation 14
[34] IMO Resolution A.1047(27) – Principles of Minimum Safe Manning af 20 dec. 2011, Annex 1, Punkt 3:
3.1.1 the capability to:
.1 maintain safe navigational, port, engineering and radio watches in accordance with regulation VIII/2 of the 1978 STCW Convention, as amended, and also maintain general surveillance of the ship;
.2 moor and unmoor the ship safely;
.3 manage the safety functions of the ship when employed in a stationary or near-stationary mode at sea;
.4 perform operations, as appropriate, for the prevention of damage to the marine environment;
.5 maintain the safety arrangements and the cleanliness of all accessible spaces to minimize the risk of fire;
.6 provide for medical care on board ship;
.7 ensure safe carriage of cargo during transit;
.8 inspect and maintain, as appropriate, the structural integrity of the ship; and

determining the minimum safe manning, is the notion that the ship´s crew must be set to be able to maintain safe watchkeeping and keep the ship properly maintained. Whether this will be possible to comply with without an on-board crew is up for discussion. In continuation thereof, the question whether a ship can have a minimum safe manning at 0 persons or not arises.

Chapter 9 of *SOLAS* involves the *ISM* code[35], as thus the following piece will analyse the actual requirements of said code. The *ISM* code requires inter alia that the company designates a so called *Designated Person* ashore to ensure the safe operation and pollution prevention of each ship.[36] Such a role may seem redundant as the crew is removed from the ship. Nevertheless, the responsibility remains in effect, but the question will be whether this duty can be given to a shore-based operator or not, as mentioned in previous section. When it comes to the master´s responsibility and authority, nothing is the *ISM* code immediately prevents the passing of such responsibility and authority to a shore-based operator. The code merely requires that the company has the master´s responsibility clearly defined in the SMS operating on board, that such master has *overriding authority* and that he is assigned the power to take decisions independently vis-à-vis the safety of the ship, its crew and the environment. Surrendering such responsibility to an operator ashore is only acceptable if he is able to be considered the master of the vessel. As a matter of fact, the term *master* is not defined in the *ISM* code nor in *SOLAS*. *STCW*[37] is the only convention to define that term, stating it as *"the person having command of a ship"*[38]. According to the dictionary *Merriam-Webster*, a *master* is *"a person licensed to command a merchant ship"*[39]. These definitions, as well as others studied, do not immediately give rise for one to claim that such a role cannot be transferred to a shore-based operator.

.9 operate in accordance with the approved Ship's Security Plan;.
[35] International Safety Management Code
[36] ISM, Part A, Punkt 4
[37] International Convention on Standards of Training, Certification & Watchkeeping for Seafarers (STCW)
[38] Annex to STCW, Chapter 1, Regulation I/1, 1.3
[39] https://www.merriam-webster.com/dictionary/master visited: 20.02.2017

The *ISM* code also requires that the company ensures that each of their ships are manned cf. national and international requirements to the qualification of seafarers (i.e. those put forward in the *STCW* for their respective positions) and in order to *"encompass all aspects of maintaining safe operations on board."*[40] The challenge lies in the latter part of the regulation concerning the maintenance of safe operations on board. As the concept of *safe operations* is not specified, questions will arise about how an unmanned ship could be operated safely and to what extent.

The maintenance requirements of the *ISM* code[41] insists on that the company establishes procedures for key shipboard operations, that regular inspections are held and that the stand-by instrumentation is checked regularly. By regular port stays, inspection staff might be able to come aboard and examine the ship and its equipment in compliance with the requirements of the law. Whether this is an option in practise is a matter also up for discussion.

Chapter 11-2 of *SOLAS* is concerned with maritime security, as referred to in the *ISPS* code.[42] The *SOLAS* chapter merely stipulates that the master must be able to take actions and decisions independently regarding the security of the ship[43], in the same way as specified in the above reg. the *ISM* code. The main question once again lies in who could be charged with and enforce such a responsibility.

At the lowest level of security, the ship must inter alia control the access to the ship and the embarkation of persons, their effects and generally keep surveillance of the ship and its close environment in security matters.[44] Surveillance could possibly be done via camera technology in compliance of the law. Whether one can control the access to the ship, the persons that embark it, their effects or not will be a question of what is meant by the term *control*.

[40] ISM Code, 6.2.2
[41] ISM Code, 10 - Maintenance of the Ship and Equipment
[42] International Ship and Port Facility Security Code (ISPS)
[43] SOLAS, Chapter 11-2, Regulation 8
[44] ISPS, 14.2

8.3 MARPOL[45]

Throughout *MARPOL* one will find the formulation *"The master or other person having charge of any ship involved in an incident…"*[46], which must indicate that *MARPOL* does not take into account whether the person in charge of the ship is physically present on board or not. The regulation neither differentiates between the responsibility of the master and the ship-owner, by which one should expect that the physical presence is not relevant for the purpose of the convention. Additionally, if the person having charge of the ship will be incapable of performing the duties imposed on him, both charterer and operator etc. will be involved with same jurisdictional responsibility for such duties. Therefore, it does not seem that unmanned ships will face major challenges in complying with the requirements of *MARPOL* from a general perspective.

8.4 STCW

First, it is important to note that *STCW* applies to *"seafarers serving on board seagoing ships…"*[47]. One might therefore question whether a shore-based operator as mentioned will have to comply with the *STCW* requirements at all. Moreover, a flag state may establish its own special requirements to the qualifications of its seafarers and maritime personnel given that these qualifications are equally safe as the once specified in *STCW*.[48] In continuation, the Annex to *STCW* states:

> *"Administrations shall require the master of every ship to ensure that watchkeeping arrangements are adequate for maintaining a safe watch or watches, taking into account the prevailing circumstances and conditions and that, under the master's general direction:*
>
> *.1 officers in charge of the navigational watch are responsible for navigating the ship safely during their periods of duty, when they shall be*

[45] International Convention for the Prevention of Pollution from Ships
[46] MARPOL, Protocol 1, Article 1
[47] STCW, Article 3
[48] STCW, Article 9(1)

physically present on the navigating bridge or in a directly associated location such as the chartroom or bridge control room at all times;

.2 radio operators are responsible for maintaining a continuous radio watch on appropriate frequencies during their periods of duty"[49]

Here we have the biggest challenge for unmanned ships in complying with *STCW*; the requirement that the officer in charge of the watch shall be physically present on the navigating bridge. It may be difficult to circumvent this regulation with an acceptable interpretation that will allow unmanned ships to live up to such requirement of physical attendance. However, should one accept the so-called navigating bridge to be transferred to the shore-based office of the unmanned ship from a legal perspective, the requirement for physical attendance will likewise be transferred to the associated control center ashore. In continuation, we once again see the requirement for the continuous radio watch as mentioned in *SOLAS* also.[50] Finally, as stated in the beginning of this segment, it is important to note that the *STCW* applies to seafarers on board ships only. Contrarily, when looking at the Danish Order on Watchkeeping[51], one will find that the requirement to the physical presence on the navigating bridge applies to all Danish ships[52] and not just the seafarers serving on board these. The challenge of the unmanned bridge will thus not depend on whether the operators are seafarers or not, but rather whether it is possible to define the shore-based control center as the bridge of an unmanned ship or not.

The term "ship" is not defined similarly in all conventions, but the terms does not in its essential definition seem to require a crew on board. Therefore, unmanned ships must comply with the same existing regulations as conventional manned ships. Some of the safety requirements in SOLAS seem obsolete for unmanned ships, which can be circumvented through the dispensation of flag states given that the safety levels prescribed are not compromised. Additionally, the ISM and ISPS codes establish requirements to the responsibility of the master, which may be transferred to a

[49] STCW, Attachment 1, Resolution 1, Annex to STCW, 1978, Regulation VIII/2 (2)
[50] SOLAS, Chapter 4, Regulation 12
[51] BEK nr. 1758 af 22/12/2006 - Bekendtgørelse om vagthold i skibe (Danish Order on Watchkeeping)
[52] BEK nr. 1758 af 22/12/2006 - Bekendtgørelse om vagthold i skibe (Danish Order on Watchkeeping), §1

shore-based operator. MARPOL, on the other hand, does not seem to differentiate such responsibility. The challenge in the manning requirements are to be found in watchkeeping and maintenance primarily. The former being the biggest legal challenge of the STCW as it requires physical presence on the navigating bridge as well as continuous radio watch.

9. The Unmanned Ship and the Insurance

The following section will investigate possible legal challenges regarding the insurance of an unmanned ship. In order to analyse the unmanned ship concept vis-à-vis insurance requirements, the British *The Marine Insurance Act 1908 (MIA)* – often used as a standard in academic work – and the Danish *The Marine Insurance Convention 1934 (DSK)*[53] will be analysed. These conventions regard property insurance. Additionally, the *Danish Merchant Shipping Act*[54] is analysed also regarding the requirements for liability insurance vis-à-vis third parties.

First and foremost, it is important to note that as the human intervention becomes increasingly restricted, the ability of the autonomous system to solve problems becomes of paramount importance – especially in cases where human interaction is no longer possible.[55] It can thus be difficult to place liability on human actions in the same way as is done with the conventional ships of today.

Most remarkable for both acts is the requirement to the ship´s seaworthiness. *MIA* has the requirement that *"there is an implied warranty that at the commencement of the voyage the ship shall be seaworthy for the purpose of the particular adventure insured."*[56] The definition of seaworthiness is given as the ship being *"reasonably fit in all respects"*[57] to encounter the common maritime hazards that will arise during the adventure insured. It is therefore expected that the ship is

[53] Dansk Søforsikrings-konventionen
[54] LBK nr. 75 af 17/01/2014 - Bekendtgørelse af søloven (Danish Merchant Shipping Act)
[55] Remote and Autonomous Ships (AAWA, 2016) s. 49
[56] The Marine Insurance Act 1908, §39(1)
[57] The Marine Insurance Act 1908, §39(4)

seaworthy for the exact adventure that it is being sent on. The question is, however, whether unmanned ships can be considered as seaworthy based on the exact adventure that it is to undertake, which in itself will take into account the "unmannedness" of the ships. Opposite the definition of seaworthiness in *MIA* as being reasonably fit in all respects, *DSK* does not have a precise definition of the term. *DSK* does however mention that the ship in continuation of its seaworthiness should be *"tilbørligt udrustet og bemandet, forsynet med de fornødne dokumenter vedrørende skib og ladning eller forsvarligt lastet"*[58]*(properly equipped and manned, provided with the necessary documents regarding ship and cargo or properly loaded)*. The two acts do therefore seem to give the same intuitive feeling of what is required of a ship´s condition prior to its venture. Exactly this can prove to be a challenge for unmanned ships, as it is unclear to what extent they will be considered seaworthy. Such obligation to make the ship seaworthy does however not implicitly mean that the ship must be in a perfect condition. More correctly, it means that the ship must be as seaworthy as it can reasonably be expected for the forthcoming journey.[59]

Additionally, requirements are established for the necessity of liability insurance cf. The *Danish Merchant Shipping Act*[60]. Such requirements do not regard the validity and extent of the agreements themselves, but indicate an obligation to have a guarantee of insurance. The ship-owner of any ship of at least 300 gross tonnage shall be insured against maritime claims[61], as presented in the *LLMC convention*[62]. Furthermore, the paragraph states that *"Skibet må ikke gå i fart, medmindre det har et certifikat, som bekræfter, at der foreligger en sådan forsikring."*[63] *(the ship may not be put into service unless it has a certificate confirming the existence of such insurance)*. In addition, a ship-owner of any ship more than 1.000 gross tonnage shall

[58] Dansk Søforsikrings-konvention 1934 (Danish Marine Insurance Convention 1934), §114
[59] The Legal Aspects of Seaworthiness: Current Law and Development, (Kassem, 2006) s.15
[60] LBK nr. 75 af 17/01/2014 - Bekendtgørelse af søloven (Danish Merchant Shipping Act)
[61] LBK nr. 75 af 17/01/2014 - Bekendtgørelse af søloven (Danish Merchant Shipping Act), §153
[62] Convention on Limitation of Liability for Maritime Claims 1976 (LLMC)
[63] LBK nr. 75 af 17/01/2014 - Bekendtgørelse af søloven (Danish Merchant Shipping Act), §153

have a similar insurance and confirmatory certificate against pollution damages caused by bunker oil[64], as presented in the *BUNKER convention*[65].

Strict requirements are thus in place necessitating that an unmanned ship is insured against maritime and pollution claims, but nothing directly prevents an unmanned ship from obtaining such insurance. The challenge may however be, as these insurance agreements usually are drawn through a P&I Club, what a possible prerequisite for membership in a P&I Club will be.

The Danish Merchant Shipping Act imposes stringent requirements to the placement of liability insurance, by which the ship will otherwise not be allowed to be used in service. Therefore, the P&I Club´s attitudes towards unmanned ships are essential, as these Clubs are the ones usually insuring shipping companies in third-party liability matters. In addition, the insurance acts put down requirements to the seaworthiness of the ships cf. MIA and DSK. Whether this includes requirements for the on-board presence of a crew or not is currently unclear, and it is thus uncertain whether the ships can be regarded as seaworthy.

[64] LBK nr. 75 af 17/01/2014 - Bekendtgørelse af søloven (Danish Merchant Shipping Act), §186
[65] International Convention on Civil Liability for Bunker Oil Pollution Damage 2001 (BUNKER)

10. Discussion

10.1 Autonomous vs. Remote-Controlled

The following segment will elaborate on the difference between an autonomous and a remote-controlled ship concept from a legal perspective.

It is important first to note the difference between the two concepts as stated in the theoretical section earlier. This segment will not be related to the unmanned nature of the ship concept, but solely discuss the legal differentiation between autonomous and remote-controlled operation.

Dr. Ringbom says:

> *"Vi måste hålla isär situationen då skipet är totalt automatiserat eller 'bara' fjärrstyrt (…) Det är en väldigt stor skillnad, också hur man löser problemet juridiskt."*[66]

(we must hold separated the situation where the ship is totally autonomous or just remote-controlled (…) It is a very big difference, also how one solves the problem legally)

Such difference can in particular be seen regarding the regulations of *SOLAS*. In respect of remote-controlled ships, one will have to assess which of the requirements could be undertaken from a remote station and to what extent. In respect of autonomous ships, one will have to assess if the requirements can be substituted with autonomous systems at all. The solution hereto will be based on whether it is possible for an unmanned ship to comply with the purpose of the law or not. *Dr. Stevens* is of the belief that they can.[67] *Dr. Ringbom* expresses that it will be possible to interpret the law in remote-controlled cases, but not in autonomous cases.[68] A solution to this, cf. *Dr. Ringbom*, could be to add an additional chapter to the conventions, extended by a separate code covering unmanned shipping requirements.

[66] Annex 2, Henrik M. Ringbom interview, line 174-177
[67] Annex 3, Frank Stevens interview, line 66-68
[68] Annex 2, Henrik M. Ringbom interview, line 174-177

Dr. Jessen believes that the greater legal challenge of the two unmanned concepts is that of the autonomous ship because human activity no longer is directly connected to the operation of the ship.[69] To challenges this position, we asked *Mr. Berger* of the German Flag State Administration, *BG Verkehr*, whether the greater challenge would be to make a ship autonomous, though keeping a few people on board without any influence on the ship whatsoever, or to make it remote-controlled with no crew. He said:

> *"Making the ship autonomous is more or less already possible today. In the engine we have watch-free operation and on the bridge we have navigational systems available allowing automatic course tracking."*[70]

Here, the challenge is primarily to be found in removing the crew from the ship rather than removing them from the operation. *Dr. Jessen´s* statement about the lack of human interaction being the greater challenge does thus not seem to be shared by *Mr. Berger*. Hence, it is obvious that the industry is divided regarding the challenges of the two unmanned ship concepts, and the valuation of such challenges.

Insurance wise, it does however seem that the lesser risk will fall for remote-controlled ships. This is caused by, cf. *Mr. Hare*, that the human monitoring still is present, as is the case for airplane pilots in the aviation industry.[71] *Ms. Hammer* on the other hand believes that it is too early to predict[72]. *Mr. Hare* also states that a large part of the current insurance claims is attributed to human error, so there may be an incentive (if the system works properly) at a reduced risk rather than an increased.[73] This will especially be relevant to autonomous ships. However, he also says that it is too early to predict anything substantial about.[74] The set-up presented therefore seems crucial as well as the extent to which it will be possible to monitor the operations of such a set-up. From an insurance perspective, ponderings are

[69] Annex 4, Henning Jessen interview, line 52-54
[70] Annex 5, Tilo Berger interview, line 163-165
[71] Annex 6, Jonathan Hare og Morten Bjerregaard interview, line 267-268
[72] Annex 7, Helle Hammer interview, line 129-130
[73] Annex 6, Jonathan Hare og Morten Bjerregaard interview, line 286-287
[74] Annex 6, Jonathan Hare og Morten Bjerregaard interview, line 287-288

ongoing through the insurance industry as implied by the majority of the thesis´ insurance research stakeholders. Intuitively, the remote-controlled concept does however seem preferable at present.

It appears that there is a significant legal difference in whether the ship is remote-controlled or autonomous. As the unmanned ships of the future lie somewhere in between the two concepts, it is difficult to assess how to tackle the ships from a legal perspective. An option could be to add new sections to current law concerning unmanned shipping, possibly supported by an underlying separate code. The industry is torn between the risk evaluation of the two concepts. Insurance wise, it is difficult to favour one concept over the other due to the novelty of the concept, but most are inclined to prefer the remote-controlled concept.

10.2 Safety and Security

The following section will discuss the safety and security requirements as set out in the analysis segment above, and assess to what extent these requirements will be challenging for unmanned ships. Onwards, it is important to note the following statement from *Dr. Stevens* about the purposes and the means of the regulations:

> *"Once the rule is there, however, we do what lawyers usually do: we forget about the purpose (safety), and the means (a crew) becomes an end in itself. The ship must be manned, because that is what the rule says. Never mind that you can now (arguably) obtain the initial purpose (safety) in a better way through other means, the rule is sacred and must be complied with"*[75]

It may therefore be worth looking at the purpose of the legislation rather than its means to obtain such purpose when talking about unmanned ships.

[75] Annex 3, Frank Stevens interview, line 58-62

10.2.1 Fire and Safety Equipment and Arrangements

SOLAS requires, as mentioned, that the fire prevention and firefighting on board is to uphold a minimum standard and training as specified, to which *Dr. Ringbom* says:

> *"Om fartyget har ett brandsläckningssystem som sköts från en annan plats, måste självfallet också utbildningen om detta basera sig på det (dvs kan ske annanstans än ombord). Om det är helt automatiserat, minskar behovet av utbildning, men i stället ökar kraven på regelbunden kontroll, redundans etc."*[76]

(if the ship has a fire extinguishing system that is operated from another location, then the education of it must obviously be based on that (i.e. it can be operated elsewhere than on board). If it is fully automated, the need for education reduces, but instead the requirements for regular control, equipment duplication etc. increases.)

If the equipment requires training, one must expect it to be adjusted accordingly i.e. completed ashore. If it is entirely automated, the need for training is lessened, which on the other hand may result in the need for more frequent regular checks, equipment duplication etc. In other words, on-board training will be considered as outdated. Looking at the overall danger of fire on board, such danger is thought to be significantly decreased on unmanned ships compared to manned.[77] It must be expected that more efficient and advanced systems will be installed on board, which would not have to take into account human biology in connection with firefighting.

If we direct our attention to the requirements of *LSA*[78], a ship must be equipped per the requirements of *SOLAS*.[79] The question is whether *LSA* should be on board at all when there is not a crew on board to save. *Dr. Ringbom* says:

[76] Annex 2, Henrik M. Ringbom interview, line 216-219
[77] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN Quantitive Assessment, 2015) s. 19
[78] Life Saving Appliances (LSA)
[79] SOLAS, Chapter III

> *"Om ett fartyg inte har en enda mänska ombord, behövs väl strängt taget inga LSA, då det inte finns några liv att rädda. Om fartyget är designat för att ibland ha folk ombord, anser jag att LSA reglerna ska gälla."*[80]

(if a vessel does not have a single human being on board, then LSA is not really required, as there are no lives to safe. If the vessel is designed to have people on board occasionally, then I believe that the LSA rules shall apply)

In other words, it is all about whether any personnel at any moment in the operation of the ship will be present on board or not. If personnel will be on board, the requirements for LSA will apply. To this *Dr. Belcher* says:

> *"Realistically you cannot remove all persons from a ship."*[81]

LSA must thus be required perpetually due to the practical impossibility of removing any personnel from the ship completely.

10.2.2 Equal Arrangements

A general remark on both the ship´s fire and safety equipment and arrangements is the option for flag states to approve equipment and arrangements that *may deviate from the presciptive requirements.*[82] This will remain an option as long as the safety level, that is the purpose of the regulations, is not neglected. This exactly will play a significant role for unmanned ships.[83] According to *Dr.* Ringbom, the flag states actually have quite a lot of opportunity to make these *equivalent arrangements*[84]. Similarly, *DNV-GL* says that we already now see that flag states are prepared to make exemptions to the conventions[85] and thus this could be the case for unmanned ships too. To this *Mr. Berger* says:

[80] Annex 2, Henrik M. Ringbom interview, line 224-226
[81] Annex 8, Philip Belcher interview, line 154
[82] SOLAS, Chapter 2-2, Regulation 17 & Chapter 3, Regulation 38
[83] Remote and Autonomous Ships (AAWA, 2016) s. 42
[84] Annex 2, Henrik M. Ringbom interview, line 214-215
[85] Annex 9, DNV-GL interview, line 134

> *"it is correct that flag States may grant exemptions and equivalents under SOLAS, however these instruments are mainly related to equipment/construction matters and not to manning issues."*[86]

In other words, flag states would be able to grant these *equivalent arrangements* dispensations regarding the equipment and construction of the ship, including firefighting and safety equipment and arrangements, but not in terms of manning. If you compare this to the earlier statement of *Dr. Ringbom* that as long as personnel is ever on board then safety equipment is required[87], the level of freedom to make deviating measures on board seems a little more limited on safety equipment compared to firefighting equipment. Nevertheless, an option could be to let the design and equipment of unmanned ships fall under the term of equivalent arrangements – the unmanned part of the ships, however, does seem to be somewhat more difficult cf. *Mr. Berger*. To this idea, *Dr. Jessen* says:

> *"We had a recent panel in Germany on this issue where a German representative to the IMO argued that no legal changes are necessary because the flag States could invoke exceptions and exemptions and "equivalent design" under SOLAS. I oppose this view, I think a lot of legal changes will be necessary"*[88]

It therefore seems that the flag states initially could give exceptions to the unmanned ships in order for them to operate, but this will not be a sustainable solution over the long term. Exactly that of getting the ships into operation seems utmost important before one can evaluate whether these equivalent arrangements actually are equivalent. In addition, it must be said that the relocation of the master/officer to a shore-based facility has a highly accident-prevention potential, but it will nonetheless not be possible to achieve a 100% faultless system.[89] The question is thus whether an

[86] Annex 5, Tilo Berger interview, line 244-245
[87] Annex 2, Henrik M. Ringbom interview, line 224-226
[88] Annex 4, Henning Jessen interview, line 63-66
[89] Can unmanned ships improve navigational safety? (TRA, 2014) s. 8

unmanned system can be designed to be safer than the manned systems of today. That is however technological matter, and not a legal one.

10.2.3 ISPS SECURITY

If we turn our attention to security matters, we first find the requirement of controlling the access on board, the embarkation of persons and their effects as well as undertaking regular safety inspections of the ship and its environment.

For the inspections, *Dr. Ringbom* believes that such requirements should be possible to comply with via video surveillance:

> *"Sen ska man väl komma ihåg att en del securityrisker (kidnappning, mord, misshandel etc.) bortfaller om fartyget är obemannat, och då kanske också preventionen kan rikta in sig på en lite annorlunda hotbild."*[90]

(one should then remember that some security risks (kidnapping, murder, abuse etc.) becomes void if the vessel is unmanned, and then perhaps also the prevention can focus on a slightly different threat image)

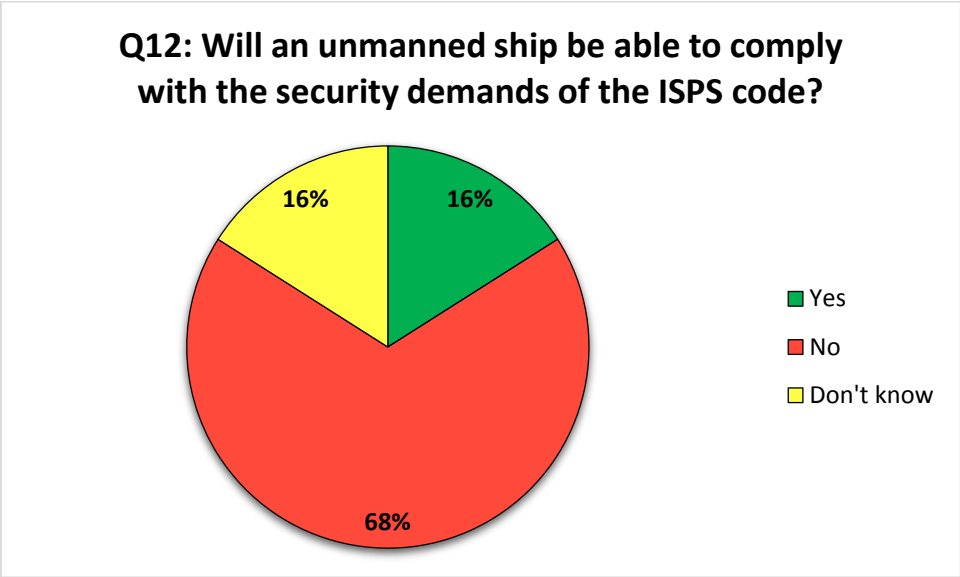
This observation is shared by *Dr. Belcher*, whom includes the controlling of access and embarkation on board as being possible. He says:

> *"… the ship could comply with the ISPS code as all access could be controlled and the ship could be made impervious to hijacking."*[91]

In other words, the ship will be designed in such a way that it will not be possible to embark. This comment is shared by one of the masters of the questionnaire.[92] Contrarily, another master believes that being on board is an important part of assessing the situation correctly. The assessment precisely will be very difficult for unmanned ship operators to make.

[90] Annex 2, Henrik M. Ringbom interview, line 300-301
[91] Annex 8, Philip Belcher interview, line 141-142
[92] Annex 10, Questionnaire, response no. 13

More than half of the masters in questionnaire believes that it will not be possible to comply with the *ISPS* code in practice:



Figur 3[93]

One of the challenges, cf. one of the masters, is the gangway watch, with which it will not be possible for unmanned ships to comply. Similarly, one will not be able to perform vessels searches before departure and during the cargo operation:

> *" With the regulation as today it will not be possible, no watch, no stowaway checks, no vessel searches…"*[94]

It should be mentioned however, that there will be a possibility of controlling the area around the ship, as well as a possible gangway if needed, from the shore personnel of the terminal during port stays, so that a physical human presence will remain for the assessment. One of the authors have seen this practised in the port of Yantian, China. This allows one to maintain a sufficient control as prescribed.

Another reason why the ship will find it difficult to comply with the *ISPS* code, cf. the masters, is the ship´s limited ability to withstand pirate attacks. To use the masters´ own words, the ship will be *"a gift for pirates"*[95]. Others believe that the

[93] Annex 10, Questionnaire, question 12.1
[94] Annex 10, Questionnaire, response nr. 19
[95] Annex 10, Questionnaire, response nr. 1

ships will not be in the interests of the pirates due to the lack of possibility to demand ransom for crewmembers. This is also indicated by *MUNIN.*[96] Yet focus should not be placed on the interests of pirates, but rather the fulfilment of the legal requirements, and the industry disagrees whether these will be complied with by unmanned ships or not.

10.2.4 The Human Element

One of the safety and security issues that repeatedly comes to show in the answers received from both research stakeholders as well as masters is the term *The Human Element*. Most insurance claims today are attributed to human error, says *Ms. Hammer*, and there may therefore potentially be some safety benefits in removing the crews from the ships replacing them with more autonomous systems.[97] However, that does strongly depend on the safety and security measures established to ensure the continuous functionality of the systems.[98] In other words, it depends on how the technical performance of the systems is going to be, and how they turn out to fare. *Dr. Belcher* is of a different position:

> *"Removing the human from factories has certainly helped in reducing accidents. But the sea is different. The perils of the sea are many. Things break and if it can go wrong then it will. (…) So some types of accidents will be removed but others will emerge."*[99]

According to *Dr. Belcher*, it will be incorrect to conclude that removing the human element from the ships by default will be successful safety wise, because other types of accident will occur as a result. *Dr. Belcher* continuous to refer to the use of aircraft pilots in the aviation industry, whom at present are not a necessity, but merely a safety measure.[100] The same would be the case for seafarers on ships, who prevent many accidents from ever occurring. Removing *The Human Element* will

[96] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN Quantitive Assessment, 2015) s. 20
[97] Annex 7, Helle Hammer interview, line 83-85
[98] Annex 7, Helle Hammer interview, line 85-86
[99] Annex 8, Philip Belcher interview, line 148-151
[100] Annex 8, Philip Belcher interview, line 165-167

likewise remove the human safety measure. Precisely the predictability, as have also been mentioned by one of the masters in the questionnaire, and reactivity from human beings are an important safety property, which can be lost by removing them from the operation.

In terms of insurance, *Ms. Hammer* says:

> *"Knowing that human error is a factor in almost all incidents leading to an insurance claim, there are potentially some safety benefits in removing the human factor and replacing crew with new and more advanced solutions on board."*[101]

This is supported by the insurance company *Allianz*, who writes that have been an increase in fatigue-related insurance claims in the previous ten years, due to the crew sizes often being as low as possible. The industry expects a future shortage of maritime workers, which could exacerbate the problem even further.[102] Others believe that the claim that an unmanned ship will remove *The Human Element*, and thereby limit maritime accidents is grossly misunderstanding towards the human involvement in the process.[103] Human error will continue to be the biggest challenge and should be treated carefully. *Mr. Hilduberg* believes that human error is not in itself a cause, but rather an event, and it can therefore not be concluded that accidents are due to human error.[104] Hence, it is unclear whether unmanned ships by losing *The Human Element* will be safer at all.

SOLAS has laid down strict requirements to fire and safety equipment and arrangements, but not to manning directly. Yet current ships cannot be made unmanned due to the requirements of the above, which however becomes outdated in the light of the non-existent crew. Flag states have the option to grant dispensation if the safety level is preserved, which may seem a temporary solution, but should not be mistaken for a long-term strategy. Towards the ISPS code, the

[101] Annex 7, Helle Hammer interview, line 83-85
[102] Safety and Shipping Review 2016 (Allianz, 2016) s. 3
[103] Situation Awareness in Remote Control Centres for Unmanned Ships (Porathe, Prison, Man, 2014) s. 7
[104] Annex 11, Øssur J. Hilduberg interview, line 95-96

opinions of the industry are divided. With regards to port stay, the unmanned ships seem capable of complying with many of the demands legally, but disagreement in the industry is found regarding piracy. Most the insurance claims today are attributable to human error, and whether such phenomenon have a potentiality to be decreased or not is likewise disagreed upon within the industry. In addition, the sea is mentioned to be of great unpredictability, to which human interaction and reaction is important in the safety of a ship.

10.3 MANNING

The following section will discuss the manning-related requirements mentioned in the analysis and assess to what extent these requirements will be challenging for unmanned ships.

10.3.1 MANNED VS. ATTENDED

UNCLOS requires that any ship is in the charge of a suitably qualified staff of officers as well as a crew of appropriate size and qualifications. The crew is however not per the regulations required to be on board the actual physical ship. In *AAWA* it I mentioned that *"manned"* not necessarily means *"attended"*[105]. Likewise, *MUNIN* states that a ship could be regarded as manned by having ship-staff manning associated ship-stations in a shore-based office.[106] To his *Mr. Berger* says:

> *"From my point of view if we talk about "manning" then we always expect that the crew is physical present on board the ship and not situated at a shore-based remote control station."*[107]

It therefore seems essential to define the exact meaning of *manning* in the different conventions.[108] It is important also to note that the current legislation is written at a time where no one had the faintest idea that unmanned shipping will be a topic of discussion in the future, and thus the means written into the law ex. the

[105] Remote and Autonomous Ships (AAWA, 2016) s. 43-44
[106] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN Quantitive Assessment, 2015) s. 75
[107] Annex 5, Tilo Berger interview, line 156-157
[108] Annex 3, Frank Stevens interview, line 58-62

abovementioned safety means, could only be attained by having a crew physically present on board. Therefore, one have never had the need to clearly define the term *manning*. This is exactly what *Dr. Stevens* point to in his statement previously quoted.

10.3.2 Minmum Safe Manning

Another challenge regarding manning is the determination of a minimum safe manning. As noted earlier, several aspects are listed which flag states are to consider when determining the manning levels of ships. The requirements comes from an *IMO* resolution[109], and as *Dr. Ringbom* says:

> *"IMO resolutionen är inte bindande i meningen att alla punkter måste uppfyllas."*[110]

(The IMO resolution is not binding in that all the point must be complied with)

Hence, not all aspects referred to in the resolution are necessary. Nor is it statutory for flag states to determine their crews after these aspects particularly. Therefore, the resolution requirements have been cut down to the for this thesis most essential: watchkeeping and maintenance.

10.3.2.1 Watchkeeping

As mentioned, a continuous physical attendance is required on the ship´s navigating bridge. To whether such regulation is possible to circumvent or not, *Mr. Berger* said:

> *"The current jurisdiction assumes that the Captain as well as the other part of the crew are physically present on board (…) It's always required that persons have to be on board carrying out essential duties like watchkeeping etc."*[111]

[109] IMO Resolution A.1047(27) – Principles of Minimum Safe Manning
[110] Annex 2, Henrik M. Ringbom interview, line 243
[111] Annex 5, Tilo Berger interview, line 200-206

Furthermore, *Mr. Berger* refers to *COLREG*[112], which requires that any ship always maintains a *full appraisal* of the navigational situation.[113] A *full appraisal* requires, cf. *Mr. Berger*, that people are physically present on board:

> *"… COLREG states in Rule 5 that every vessel shall at all times maintain a proper look-out by sight and hearing. (…) It's always required that persons have to be on board carrying out essential duties like watchkeeping etc."*[114]

Thus, the navigational officer of the watch cannot keep a proper safe watch without being on board. Thereto, *Dr. Stevens* believes that:

> *"I would say that it is possible to make a 'full appraisal' without physically being on board of the ship. Technology obviously has its limitations (...) But human crew members also have limitations."*[115]

In addition, *Dr. Stevens* state that if the shore-based operator is trained and familiarised with the technology he is to operate, he will be able to make a *full appraisal*[116] – which is in line excellently with *Dr. Ringbom´s* previous statement on safety training.[117] This will also be the case for autonomous ships, as the inputs available to the shore-based operator will be the same for the navigational system of the ship. In other words, it may well be possible to make a *full appraisal*. This stands in stark contrast to *Mr. Hilduberg´s* statement on the perception of the navigational watch at sea:

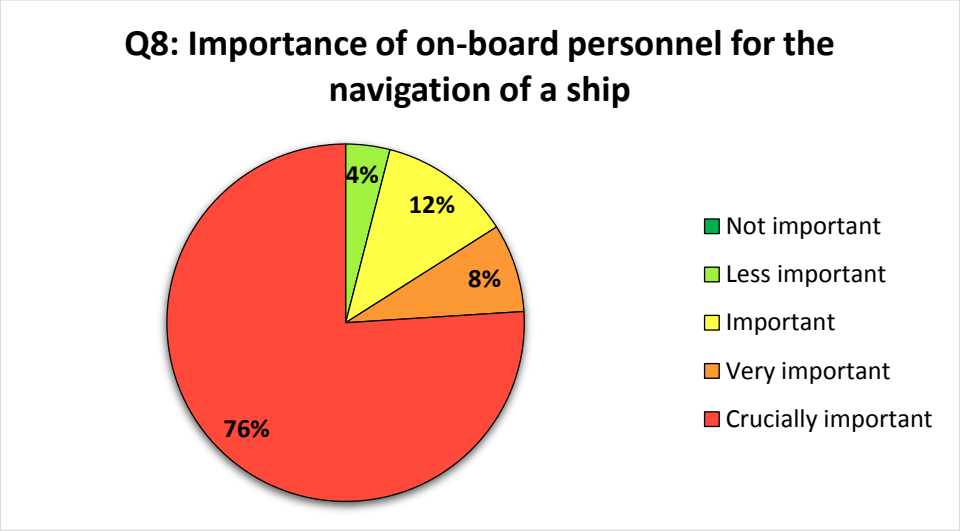
> *Beslutningen om at flytte styringen fra skibet til et eksternt sted skal bero på en viden om, hvad man laver på broen. (…) Det vil være en*

[112] International Regulations for Preventing Collisions at Sea
[113] COLREG Rule 5: "… a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision"
[114] Annex 5, Tilo Berger interview, line 203-206
[115] Annex 3, Frank Stevens interview, line 169-172
[116] Annex 3, Frank Stevens interview, line 173-175
[117] Annex 2, Henrik M. Ringbom interview, line 216-217

fejlagtig slutning at lave, at besætningen på broen udelukkende styrer skibet til bestemmelsesstedet. Der foregår mange ting knyttet til skibets drift, men også i forhold den måde som skibet agerer på i forhold til omverdenen.[118]

("The decision to move the navigation from the ship to an external location must be contingent on the knowledge of what one is doing on the bridge. (…) It will be an erroneous conclusion to say that the crew on the bridge solely steers the ship to its destination. There are many things related to the operation of the ship, but also in relation to the way the ship acts towards its surroundings.")

It is evident that the industry is divided in its opinion on the possibility of transferring the navigational watch ashore. Generally, the masters believe that on-board personnel - and thus also the physical watchkeeping on board - is essential to the navigation of the ship:



Figur 4[119]

In addition, a problem will arise if an unmanned ship that does follow the rules encounters a manned ship that does not necessarily follow the rules consistently:

[118] Annex 11, Øssur J. Hilduberg interview, line 123-127
[119] Annex 10, Questionnaire, question 8.1

> *" If all ships are run through computers = ok. But that will never happen. Unmanned ships will follow the rules - manned ships sometimes don't!"*[120]

It is here suggested that if all ships were sailing unmanned following the same coding, a problem would not arise. The problem is therefore to be found in that not all manned ships follow the navigational rules of the sea, as stated in *COLREG*. This may be a result of the manned ships´ navigators´ assessment of the concept *good seamanship*, but the question would then be whether the computer or the human would be best at such a term. *Van Hooydonk* also questions how autonomous systems will demonstrate *good seamanship*[121], but it seems from the above comment that the free interpretation of such term is exactly what might be a challenge.

To this, one of the masters believe that the physical presence is important due to the ability of the navigator to anticipate situations, as mentioned earlier.[122] Being able to avoid getting into a situation that requires bold manoeuvring by constantly predicting ahead cannot be replaced by a computer. Continuing on this, *MUNIN* wrote the following in their project:

> *"There will be no physical connection between the human and the vessel, and no directly perceived information from the ship's environment. Specifically, the visual perception of the environment, a vital sense in ship handling for bridge officers, will be lost."*[123]

MUNIN and the master hereby confirms one another by claiming that one will lose some of the sensation that an on-board officer has with the ship and its environment due to the lack of physical presence on board. Situational knowledge and awareness is not collected through navigational instruments, but rather through the senses of the

[120] Annex 10, Questionnaire, response no. 3
[121] The law of unmanned merchant shipping – an exploration (Hooydonk, 2014) s. 414
[122] Annex 10, Questionnaire, response no. 9
[123] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN Quantitive Assessment, 2015) s. 85

officer: to feel and sense the ship´s movement in the sea.[124] This is of great importance to the safety of navigation and proper watchkeeping, and is something that will possibly be lost with a shore-based operator.[125] The ship could therefore be subjected to more violent forces than if there had been an on-board officer to assess the situation – or even completely avoid it at all through his predictions. *Dr. Ringbom* does however see a different approach:

> *"Man kan lika gärna tänka på en trött, eller berusad vakthavande officer som somnar. Eller t.ex. värmekameror som uppfattar saker ett mänskligt öga inte ser. Det är klart att det i vissa situationer kan vara säkrare med folk ombord, men det utesluter inte att det i andra situationer kan vara säkrare att låta maskiner ta över.(…) I en fjärrstyrningssituation har man möjlighet att kombinera det bästa av de två, åtminstone gällande skipets manövrering."*[126]

("One might as well think of a tired or drunk officer on the watch who sleeps or f. ex. heat-reacting-cameras that picks up on things that a human eye does not see. It is obvious that it in some cases would be safer with people on board, but that does not exclude that it in other situations could be safer to let machines take over (…) in a remote-controlled situation, one has the opportunity to combine the best of the two, at least in the manoeuvring of the ship.")

Dr. Ringbom believes that one should try to combine the best from the navigator and the automation. Thus, he disagrees with the assertion of the on-board officer and his sensuality. Actuality, the officer of the watch will be better equipped to carry out a *full appraisal* as well as to navigate the ship from a less stressful environment ashore. Additionally, unmanned ships will release the officers from routine tasks, such as safety inspections, and allow them to focus solely on more cognitive demanding tasks during navigation.[127] Some of our research stakeholders and masters also mention the

[124] Situation Awareness in Remote Control Centres for Unmanned Ships (Porathe, Prison, Man, 2014) s. 4
[125] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN Quantitive Assessment, 2015) s. 44
[126] Annex 2, Henrik M. Ringbom interview, line 308-314
[127] Developments-toward-the-unmanned-ship (Rødseth, Burmeister, 2012) s. 10

possible challenge that may arise as a result of equipment failure, making it important to have the officer on the watch physically present on board to react hereto. This will be elaborated upon in the maintenance segment. All in all, there is unclarity and disagreement within the industry regarding the navigational watch, its possibilities and its challenges.

10.3.2.2 Radio Watch

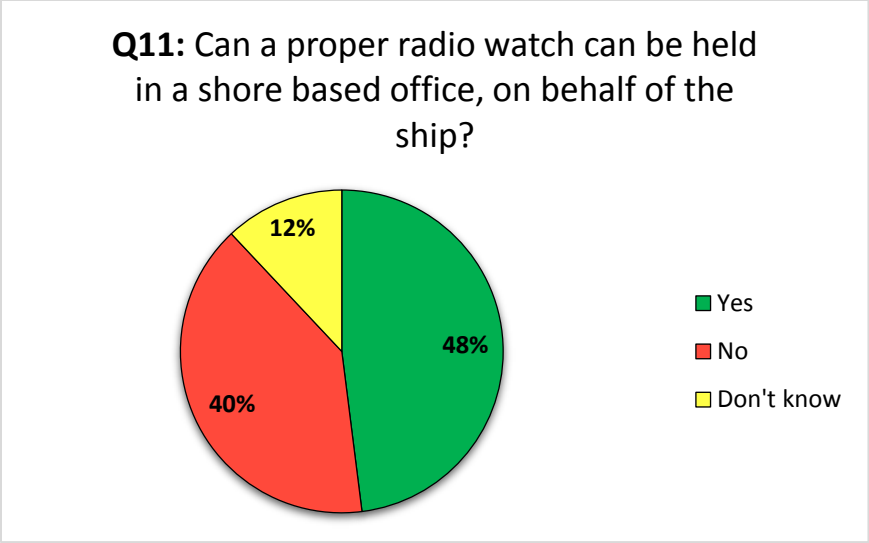
In continuation of the above, *STCW* also requires that a continuous radio watch is kept when the ship is at sea[128], which is also mentioned in *SOLAS*[129]. Contrasting to the navigational watch, nothing in the regulations states that the radio watch is to be kept on board physically. To his *Dr. Ringbom* believes that:

> *"Relay kan ske helt automatiskt och förutsätter inte att någon är ombord. Så det här ser jag inte som problematiskt att överföra till land helt och hållet."*[130]

("Relay can be done completely automatically and does not assume that anyone is on board. So this I do not see as problematic to transfer ashore completely.")

The possibility of relay radio communication from ship to shore will cf. *Dr.* Ringbom meet the legal requirements of the radio watch. Therefore, it will theoretically be possible to comply with the regulations. As regards the practical watchkeeping, it is seen clearly that the masters are split in opinions:

[128] STCW, Attachment 1, Resolution 1 Annex to STCW 1978, Regulation VIII/2 (2)
[129] SOLAS, Chapter IV, Regulation 16.1
[130] Annex 2, Henrik M. Ringbom interview, line 235-236



Figur 5[131]

A master writes that the radio support one presently can observe in many ports can be used for the radio watch of ships as well.[132] However, this depends heavily on the possible connection with the ship. *DNV-GL* illuminates this in their *Technology Outlook 2025:*

> *"In the next decade, a variety of new communications technologies will be deployed: cellular networks in coastal areas; VDES (new data service on the VHF band); Wi-Fi in ports, and, most importantly, satellite communications, improving coverage and bandwidth."*[133]

This technological description supports *Dr. Ringbom* to some extent regarding the possibility of radio relay.[134] One of the masters contrarily believes that the communicating parties should be in sight of one another and not 3000 miles apart – at least not in the case of anti-collision communication.[135] It does however not directly seem that this is a legal impossibility, but rather a practical inconvenience. In addition, some masters are sceptical of how one would maintain the radio watch continuously if the unmanned ship is experiencing a technical problem with the radio

[131] Annex 10, Questionnaire, question 11.1
[132] Annex 10, Questionnaire, response no. 14
[133] Technology outlook 2025 (DNV-GL, 2016) s. 44
[134] Annex 2, Henrik M. Ringbom interview, line 235-236
[135] Annex 10, Questionnaire, response no. 19

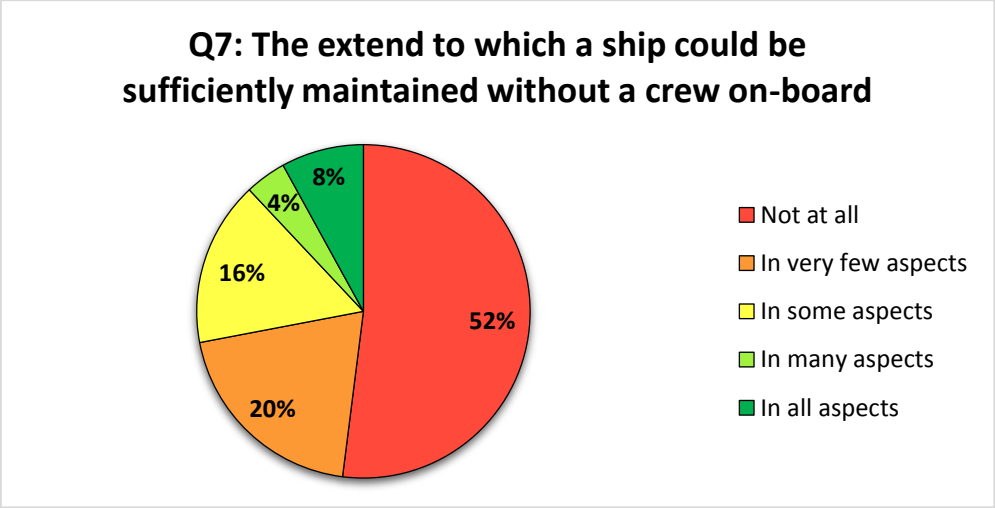
equipment on board,[136] though this is considered to be a maintenance issue rather than a watch keeping issue.

10.3.2.3 MAINTENANCE

One of the most challenging points mentioned i.e. the minimum safe manning of unmanned ships, is the requirement to maintain the equipment on board continuously functionable. *Dr. Bertram* says, among other things, that:

> *"Technological hurdles lie in the maintenance requirements of current ships."*[137]

He does not explicitly state that it is impossible to keep the equipment functionable, but that it is precisely in the maintenance requirements that unmanned ships will be facing challenges. More than half of the masters questioned believe that it will not be possible at all to maintain a ship sufficiently without a crew – for example, because things break down even with the current planned maintenance.[138]



Figur 6[139]

It is important here to note the *ISM* requirements on maintenance. These are based on the establishment of procedures and not on the actual level or design of the

[136] Annex 10, Questionnaire, response no. 10
[137] Annex 12, Volker Bertram interview, line 130
[138] Annex 10, Questionnaire, response no. 3
[139] Annex 10, Questionnaire, question 7.1

maintenance work and the regular inspections. Yet still there are cases where the planned maintenance proves to be insufficient – even after meeting the *ISM* requirements. In continuation, the following *Dr. Belcher* comment should be noted:

> *"Driverless cars are getting near to the safety levels of a driven car. (…) But the sea is different. The perils of the sea are many. Things break and if it can go wrong then it will. Then how do you fix it?"*[140]

Similar answers can be found with the masters questioned.[141] The challenge is therefore in making the ship operational again after a fault rather than in keeping the ship operational continuously. Thus, the maintenance challenge is primarily the response to things breaking down. For the time being, a sufficient functionality is not maintained anyway, as it is argued that currently things still break down unexpectedly. In addition, it is important to note the operational challenges one might face by undertaking maintenance tasks during port stays. A master writes:

> *"Most the vessels maintenance is done at sea. There is not sufficient time to only maintain in port"*[142]

The option of keeping an adequate maintenance by only carrying it out during port stays, is not a practical option for ships presently. *Dr. Belcher* is convinced that it will be too expensive for the shipping companies to take the ship out of service in order to repair what one otherwise could have kept maintained.[143] This argument we also see presented among the masters. Generally, there is disagreement about whether maintenance could be carried out during port stays or not. The argument concerning the heavy price is not immediately a legal challenge, but rather a financial or business challenge. However, if one looks at the systems on board unmanned ships themselves, *Dr. Ringbom* believes that these will require significantly less maintenance compared to current systems,[144] and will thus have different maintenance needs and options.

[140] Annex 8, Philip Belcher interview, line 148-150
[141] Annex 10, Questionnaire
[142] Annex 10, Questionnaire, response no. 18
[143] Annex 8, Philip Belcher interview, line 158-159
[144] Annex 2, Henrik M. Ringbom interview, line 249-250

One will therefore be able to find that the ships would be adequately maintained via their regular port stays. *Dr. Ringbom* says:

> *"I praktiken vill förarlösa fartyg i längden bli konstruerade på annat sätt, för att minimera behovet av underhåll ombord. Mindre rörliga delar i maskineriet, mer moduler som kan bytas ut i land och repareras på land (som flyg) och, där det inte lyckas, redundans."*[145]

("In practice, unmanned vessels will be designed in different ways, to minimise the need for maintenance on board. Less moving parts in the machinery, more modules that can be replaced ashore and repaired ashore (as aeroplanes) and, if that does not succeed, double-equipment.")

First mentioned challenge of maintaining a functional level on board will in this instance be ensured by equipment duplication, and there will thus be technical solutions to the challenges declared.

10.3.3 The Role of the Master

As mentioned, *UNCLOS* requires that any ship is under the command of a master.[146] *UNCLOS* has no definition of a master, but *STCW*, which do have a definition, does not indicate black-on-white that he needs to be on board.[147] *MUNIN* writes that even though the duties of the master have been reduced, he will still be held liable legislatively when something goes wrong with the ship.[148] To this *Dr.* Ringbom says:

> *"Jag ser inga problem med att ha en master iland om han/hon sköter alla uppgifter som en traditionell master gör. (...) I förlängelsen, kunde man kanske t.o.m. tänka sig att ett helt automatiserat skip har en*

[145] Annex 2, Henrik M. Ringbom interview, line 249-252
[146] UNCLOS, Artikel 94 (4)
[147] Annex to STCW, Chapter 1, Regulation I/1, 1.3
[148] Maritime Unmanned Navigation through Intelligence in Networks (MUNIN Quantitive Assessment, 2015) s. 86

'designated captain' dvs en naturlig person som ansvarar för fartyget även om den inte är aktivt engagerad i framförandet."[149]

("I see no problem in having a master ashore if he/she cares for tasks as a traditional master does (…) in continuation, one might even image that a fully autonomous ship has a ´designated captain´, that is a natural person responsible for the vessel even if he is not actively engaged in the actual operation.")

Dr. Ringbom supports the idea of transferring the master ashore if the ships are unmanned. The role will remain and with it the legal responsibility and liability, but just ashore. Furthermore, one could imagine that a *Designated Captain (DC)* will be appointed, who, although not directly involved in the operation of the ship, still is legally accountable. By introducing the *DC*, one may see the role of the *DP* becoming more redundant, with it possibly being implemented under the role of the *DC*. Currently, this is speculation entirely. *Dr. Stevens* supports the idea of a *DC*:

"I'd guess that there are actually no issues that you can't solve in another way than by having a Master physically on board"[150]

Mr. Berger, however, is of a different position. He does not believe that it will be possible to remove the master from the ship – at least not under compliance to current jurisdiction:

"The current jurisdiction assumes that the Captain as well as the other part of the crew are physically present on board. Consequently, the position of the Captain is part of the shipboard organization and cannot be allocated to a shore-based person."[151]

[149] Annex 2, Henrik M. Ringbom interview, line 266-270
[150] Annex 3, Frank Stevens interview, line 79-80
[151] Annex 5, Tilo Berger interview, line 200-202

It is thus seen that the industry once again is split in opinions regarding the possibility of transferring the role of the master ashore. [152] Therefore, the current legislation must be amended to allow for the possibility of a shore-based authority.

From an insurance perspective, *Mr. Hare* is supportive of the idea of a *DC*:

> *"Both laws and insurance policies refer to masters/captains so it would make sense for there to be a designated captain."*[153]

This conviction is supported by *Mr. Bardot*, who believes it is important to have a responsible figure in connection with the safety and navigation:

> *"It is early days, but it is likely that remotely operated autonomous ships will have a "designated captain or captains" based ashore and with responsibilities relating to the safe operation and navigation of the vessel just as if they were on board."*[154]

This must also be thought to be important even if the person is not, as *Dr. Ringbom* says, directly involved with the operation of the ship. The question is, however, whether one could have a responsible person ashore – even if personnel is still on board (say during port stay) – and exactly this is disagreed upon within the industry.

The industry disagrees about the definition of manned and unmanned, by which it seems essential first and foremost to clarify what the terms manned and unmanned are. The two most important points in refence to the determination of the minimum safe manning of an unmanned ship are watchkeeping and maintenance operations, both of which splits the opinions of the industry. The watchkeeping is requiring to have a physical presence on the navigating bridge, and it is too early to conclude if one can designate the shore-based control center as the ship´s bridge in legal terms. The requirement for to the physical presence derives from the assessment requirement of making a full appraisal, and the industry disagrees on

[152] Annex 8, Philip Belcher interview, line 131-132
[153] Annex 6, Jonathan Hare og Morten Bjerregaard interview, line 334-335
[154] Annex 13, Andrew Bardot interview, line 175-177

whether such appraisal can be carried out ashore or not. The possibility of undertaking the radio watch ashore seems imminent. However, the masters disagree: not because of the possibility legally, but the quality of such watch. Regarding maintenance, the industry is also divided in its opinions primarily due to the unpredictability of the current systems. If the required level of safety put forward in the international conventions cannot be met continuously throughout the ship´s journey, the flag states are expected to not approve the minimum safe manning of the ship to zero. The industry is also split over the possibility of transferring the role of the master ashore; a so-called Designated Captain. The role of the master is not clearly defined, which is the reason for said disagreement. Insurance wise, the role of the master is also important, but here the incentive to have a shore-based master is supported.

10.4 SEAWORTHINESS

Following section will in continuation on the above two discussion sections debate the insurance-related requirements as found in the analysis, and assess to what extent these requirements will be challenging for unmanned ships legally.

First, it is extremely important to assess the seaworthiness of unmanned ships – especially as this criterion is highly prioritised within the insurance industry. *Dr. Stevens* says:

> *"A 'normal' ship these days cannot operate without a crew, and thus would indeed not be seaworthy without a crew"*[155]

Current ships will thus at present not be seaworthy without a crew. *Dr. Stevens* does however continue to say that the size of the crew already now has seen major changes over the past 20 years[156], by which manning may not be as necessary as originally thought. *Dr. Ringbom* adds:

[155] Annex 3, Frank Stevens interview, line 186-187
[156] Annex 3, Frank Stevens interview, line 187-189

> *"Om automaitken fallerar kan jag gott tänka mig att ett annars sjödyktigt skip förlorar denna sjödyktighet. Inte bara under Sjölagens kap 13, men mer generellt. IMO-konventionerna har inte uttryckliga krav på sjödyktighet."*[157]

("If the automation fails, I can imagine that an otherwise seaworthy ship loses this seaworthiness. Not just under the Merchant Shipping Act chapter 13, but more generally. The IMO conventions do not have explicit requirements to seaworthiness.")

Unmanned ships would therefore as a matter of principle be able to be considered seaworthy cf. *Dr. Ringbom*, but such seaworthiness will be lost as the ship loses its automated systems. In addition, it is important to add that in regime of insurance, the requirement of seaworthiness only applies at the beginning of the voyage as a basis. Therefore, the abovementioned annotation regarding the possibility of automatic failure during the journey will not, as a rule, affect the seaworthiness, unless otherwise stated in the insurance policy. As *Dr. Ringbom* mentions, the IMO conventions do not explicitly require seaworthiness[158] and in terms of insurance one can exercise freedom of contract to great extent.

The surveyed masters indicated that the ship would not be considered seaworthy:

[157] Annex 2, Henrik M. Ringbom interview, line 321-323
[158] Annex 2, Henrik M. Ringbom interview, line 243

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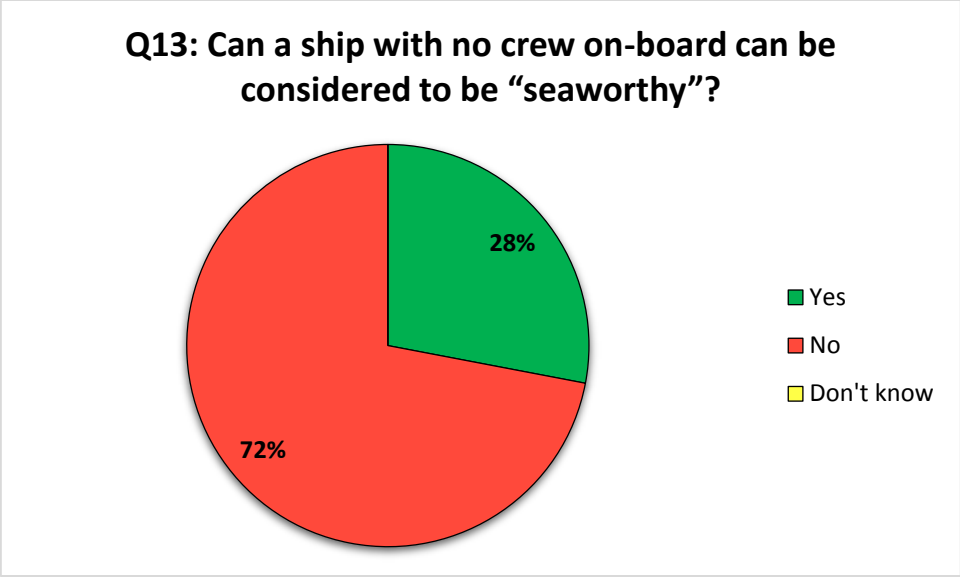

Figur 7[159]

The decisive factor regarding the unseaworthiness was the assumption that the term is based on the crew on board primarily, and the unmanned ships would thus not comply with the minimum safe manning determination.[160] In addition, the challenge of the unpredictability of a marine adventure is reiterated, as it is believed to be impossible to prepare for. Those who on the contrary believe that a ship would be able to be considered seaworthy refers inter alia to the options for flag states to customise the requirements[161] e.g. under *equal arrangements*. Throughout the comments of the masters, it is seen difficult for the ship to fulfil its obligations without a crew, but the definite requirements to manning are not to be found in the actual requirements of seaworthiness. In other words, seaworthiness does not indicate if a ship can fulfil its obligations to others at sea, but solely if the ship can undertake the forthcoming adventure to a certain level of safety. Also, *DSK*[162] states that the ship, in addition to being seaworthy, must be manned properly. Thus, it must be expected that manning is not a topic under the definition of seaworthiness itself – at least not in Danish insurance law.

[159] Annex 10, Questionnaire, question 13.1
[160] Annex 10, Questionnaire, response no. 19
[161] Annex 10, Questionnaire, response no. 22
[162] Dansk Søforsikrings-konvention

10.4.1 Insurance Risk

Moreover, one could ask the question of whether unmanned ships are a risk that underwriters are willing to insure at all or not. To this, *Dr. Stevens* says:

> *"Insurers are primarily concerned with risk. If they are confident that the new technology will work without (too many) problems, they will insure unmanned vessels."*[163]

Ultimately, it all comes down to the faith in and trust of the technology on board. *Dr. Stevens* also believes that underwriters are already now insuring matters with a significantly higher risk than unmanned shipping will have.[164]. This is followed by *Ms. Hammer* saying:

> *"In the end, it will all come down to the risk appetite of the insurers to determine whether a risk is at all insurable."*[165]

One may possibly see "hungry" underwriters whom gladly insure the risk of unmanned ships. This may however be reflected in the insurance policy clauses. *Mr. Hare* commented on the same subject that it is a standard insurance requirement that the ships are fully classified (usually with an *IACS*[166] member), and complies with all the requirements put forward by the respective flag state.[167] Therefore, as a basis, underwriters will not question the "unmannedness" of the ships, if they can be approved by an authoritative entity such as the respective class or flag state. However, *Ms. Hammers* says that as an underwriter, one will prefer clear international regulations rather than national alternatives,[168] by which one will hope that the flag states do not set their own distinct demands.

Mr. Hare mentions that the insurance industry also has a client concern:

[163] Annex 3, Frank Stevens interview, line 189-190
[164] Annex 3, Frank Stevens interview, line 190-193
[165] Annex 7, Helle Hammer interview, line 99-100
[166] International Association of Classification Societies Ltd.
[167] Annex 6, Jonathan Hare og Morten Bjerregaard interview, line 268-270
[168] Annex 7, Helle Hammer interview, line 181-182

> *"The first unmanned vessels may be operated by the established and sophisticated operators who have the ability to make the necessary investment in systems, training etc. and who will make sure they are operating in a safe way. These owners may operate large and diverse fleets and be seen by insurers as valuable clients and an overall good risk. (…) In contrast, a new operator or a small operator who sees unmanned vessels purely as a cost cutting exercise may face difficulty in finding insurance, at least in an International Group Club."*[169]

The insurance interest will consequently also depend on the company forwarding the idea of unmanned ships. If it is one of the major operators, with good insurance statistics and high market share, underwriters will be more willing to accept the risk profile of the ship. Otherwise one would fear that the company will insure its ship with another underwriter, and with that possibly also his conventional manned ships. In other words, one might risk losing a large client. Also, it depends on the usage and purpose of the ship in questions. Will it be sailing in coastal waters or across the Atlantic etc.? The different types of voyages will have different types of risks, and thus the insurance requirements will be different also. These may aslo vary greatly, as *Ms. Hammer* says:

> *"The parties to an insurance agreement can of course always make necessary adaptions to a contract to make a risk insurable. Other than the premium itself, these will include the use of higher deductibles, writing smaller shares of a risk (hull & machinery) or adding safety regulations (in addition to class and regulations)."*[170]

Consequently, measures may be taken for the perceived risks that could make the ships, which would otherwise be unwanted, insurable.

[169] Annex 6, Jonathan Hare og Morten Bjerregaard interview, line 277-284
[170] Annex 7, Helle Hammer interview, line 100-103

10.4.1.1 PRODUCT LIABILITY

A possible measure to the risks as mentioned may be the introduction of *product liability*[171] towards the autonomous systems. To this, *Mr.* Hare says:

> *"As a P&I club we provide cover for liabilities towards third parties. If we agree to insure an unmanned ship, it would follow that we would cover liabilities towards third parties…"*[172]

In other words, a P&I club will be liable for damages towards third parties, and if it is not prepared to undertake this responsibility, *Mr. Hare* believes that one should then not insure said ship. *Ms. Hammer* has a similar statement:

> *"… there are always regress possibilities against manufacturers of any component onboard a vessel, if deemed relevant and worthwhile by insurers and their clients. Any supplier to the shipping industry should therefore consider their potential exposure in this respect, and the need thereafter for any liability insurance"*[173]

As a starting point, the insurance claim will be compensated by the P&I club, but should they find it relevant, the club can subsequently seek for recourse from the manufacturer of the autonomous system and its related components. A statement from *Mr. Bardot* is along the same lines.[174] *Product liability* does therefore not seem to be the immediate solution to make the ships insurable as the P&I clubs basically will take on the responsibility. Also, recourse possibilities will act as an indirect form of *product liability* for the P&I clubs against the product manufacturers.

[171] Remote and Autonomous Ships (AAWA, 2016) s. 52
[172] Annex 6, Jonathan Hare og Morten Bjerregaard interview, line 298-299
[173] Annex 7, Helle Hammer interview, line 140-143
[174] Annex 13, Andrew Bardot interview, line 144-147

10.4.1.2 DUPLICATION OF EQUIPMENT

Another possible insurance measure, as mentioned by *Dr. Ringbom*, is *duplication of equipment*.[175] If one system fails, another will take over immediately until it is possible to correct the fault of the first system. To this *Ms. Hammer* says:

> *"This may be one of the requirements to make the risk insurable, but more work needs to be done before concluding on this."*[176]

It should be noted though, as *Mr. Bardot* mentions, that this largely depends on whether *duplication of equipment* becomes statutory or voluntary.[177] One of the masters likewise has a comment indicating the option of *duplication of equipment*:

> *"Proper design of the bridge integrated console (like double equipment) can and will replace a human in future."*[178]

It therefore seems that *duplication of equipment* very well may be an option to make otherwise non-insurable ships into insurance candidates. Again, the focus will be on whether the flag states and the class approves the ships, and whether it will be statutory or not.

A possible legal challenge may arise if the ships cannot find an insurance guarantee for the statutory insurances. Otherwise, they will not be allowed to be put into service. Legally there is no direct requirement for seaworthiness, but the requirement may come to show indirectly via insurance requirements. The industry is once again split regarding whether a ship will be considered seaworthy without a crew, although the majority agrees that unmanned ships generally will face difficulties in meeting the requirements for seaworthiness. A clear attitude from the underwriters is that if an unmanned ship is approved and certified by a flag state and the classification society, there are no immediate challenges in drawing insurance contracts with the ships. This also depends on the faith and trust towards the

[175] Annex 2, Henrik M. Ringbom interview, line 250-252
[176] Annex 7, Helle Hammer interview, line 146-147
[177] Annex 13, Andrew Bardot interview, line 150-152
[178] Annex 10, Questionnaire, response no. 12

technology, the company that presents the idea and the possible adjustments of terms in the insurance policy. This could e.g. be the introduction of a requirement for duplication of equipment installed on board. Product liability does on the other hand not seem to be the way forward to begin with (due to the possibility of seeking recourse already now). Additionally, one can expect that underwriters would like to be associated with the concept if it is perceived positively within the industry.

11. METHOD CRITICISM

The following section will reflect on the used methodological approach and the author´s criticism hereto.

11.1 CRITICAL RETRIEVAL OF INFORMATION

Our retrieval of information was carried out under strict critical selection. The initial wider retrieval gave a lot of hits on older articles and documents. They have been unselected as we have focused on having the newest possible empiricism represented. Only parts of the latest empiricism have been available online, but our participating professionals have helpfully provided us with absolute state-of-the-art empiricism. We have considered our sources to be of high validity, as we include international conventions, Danish law as well as research reports and outlooks from established professional and academic bodies. Additionally, we have received empirical data from international authorities, classification societies, international P&I clubs, ministerial agencies and accredited maritime lecturers, doctors and lawyers

Our log of singular words and word combinations used in the retrieval of information could have been more structured, which means that we may have overlooked a source or empiricism that could have highlighted another angle of the topics in question.

11.2 CRITICISM OF THE QUESTIONNAIRE SURVEY

Our questionnaire survey specified to practicing masters was through a PILOT group screening before being used formally, as mentioned. It could be argued that a larger PILOT group should have been chosen (instead of six), but the difficulty of getting in touch with practising masters willing to aid with this part of the survey made it necessary to accept the size of the PILOT group. It turned out that not everyone was able to open the newest *Word* filetype, in which the questionnaire was created. We therefore tried to convert the questionnaire into .pdf format – also so that the questionnaire could be answered from tablets, but this ended up creating new issues to which the result was that we created an identical questionnaire survey

in *Google Forms* (and ignoring the .pdf format). In addition, we changed the *Word* filetype to an older version, compromising the layout of the questionnaire, but allowing it to be opened on the ships´ computers.

As the questionnaire was sent out in appropriate format, a deadline of five days was chosen for the respondents to answer within. This was done to highlight the seriousness of the questionnaire so that it was not pushed aside and forgotten by the respondents. This may possibly have affected the number of responses received. In a single case, the actual questionnaire form was forgotten in the e-mail to the ships at first sending, but few minutes later another e-mail was send out with the questionnaire attached. The link to the Google Forms questionnaire, however, was included in the first e-mail delivery. This could have affected the response rate of the persons involved.

230 masters from different companies have had our questionnaire available, from which 25 responses have been received. The response rate is thus 10,87%[179], which can make it difficult to decide whether it is representative of the industry or not. We have contacted as many shipping companies as possible. Some companies never returned our approaches, and only two companies responded that they did not wish to participate in the study. The representability is therefore also affected by the lack of participation from the different types of cargo ship companies. Thus, our responses also have the uncertainty that a larger number of the respondents are employed within the same type of cargo ship, namely tankers. The generality of the masters may therefore have focused more on some legal challenges than the norm would, due to that most of the answers are based on tanker specific experiences.

11.3 Criticism of E-mail Correspondence

The contact with some of our research stakeholders was established too early in our research, as they were ready to answer our questions immediately. This was however recommended by our supervisor to ensure that the contact would be established in time. Our thesis is structured in layers, and in order to ask qualified

[179] 25 responses /230 masters * 100 = **10,87%**

questions to our research stakeholders, we had to wait for the empiricism of the previous level to be completed. However, the early contact with some research stakeholders made us able to get inspiration from their immediate opinions and use these in our further acquisition of empiricism. After our deadline for data processing, we have received several additional responses from research stakeholders as flag states, scholars and NGOs, which possibly could have highlighted the topic in a different angle. Moreover, we have also received documents which have not been included in the research due to the late receipt.

11.4 *Remote and Autonomous Ships, AAWA*

One of this research´s elementary documents[180] belongs to *Rolls-Royce*, and has in it a *copy right*. The document has been found online at *Rolls-Royce´s* own website at the following address:

http://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aawa-whitepaper-210616.pdf

The address is last checked: 19.03.2017 - 20:55

We do not believe that we violate any rights by using this document as it has already been published by *Rolls-Royce* themselves.

[180] Remote and Autonomous Ships (AAWA, 2016)

12. CONCLUSION

Through the research above, the following thesis question was to be answered:

What legal challenges arise from the operation of unmanned cargo ships?

This thesis concludes that there is a significant legal difference in whether the unmanned ship is remote-controlled or autonomous. The concepts of unmanned ships of the future alternate between both stages continuously, making them difficult to define legally – and that will in itself be a legal challenge in their operation.

With regards to *SOLAS*, this thesis concludes that unmanned ships will face legal challenges in complying with the requirements of the convention regarding firefighting and safety equipment, as these are based on the presence of a crew aboard to achieve the safety levels desired. The flag states could grant dispensation to the unmanned ships as long as the level of safety is not compromised, but this is not to be mistaken for an actual long-term solution. The unmanned ships will therefore be highly challenged legally in complying with this part of *SOLAS*.

The *ISM* and *ISPS* codes both have requirements regarding the responsibility of the master, and this thesis concludes that the industry is torn between whether this responsibility can be transferred to a so called *Designated Captain* ashore or not. Currently, this is a true legal uncertainty, which will be a challenge for unmanned ships. *MARPOL*, on the other hand, will not immediately be a challenge as the convention does not differ between the master and the ship-owner, and this approach could be a possible solution to the above.

In terms of *ISPS* security, this thesis concludes that the industry is torn once again, which likewise indicates that there is a possibility that unmanned ships will face legal challenges in complying with the requirements of the code. This primarily derives from the phenomenon of piracy, which will be a real difficulty to respond to.

Furthermore, this thesis concludes that the industry disagrees on what is implied by the term *manned*, and it is thus essential for unmanned ships to have legally clarified in the law what the concept entails. Until then, unmanned ships will face

legal challenges due to the lack of definition as to whether they are actually manned or not.

With regards to the minimum safe manning of an unmanned ship, this thesis concludes that watchkeeping and maintenance are the two most essential elements to be considered. The industry is torn in terms of the ability of unmanned ships to comply with these requirements. The physical presence aboard the ship´s bridge creates legal challenges for unmanned ships if one cannot accept the shore-based control center as the ship´s bridge. It is however possible for the ships to carry out their radio watch ashore. The challenge here will be found in the quality of the watch, which will not be of legal nature. Regarding maintenance, the industry is also split in opinion. It will to a certain extent depend heavily on the new automated systems, and if the required level of safety cannot be continuously upheld cf. the international conventions, then the flag state should not approve a minimum safe manning of zero.

This thesis further concludes that another legal challenge will arise if the ships cannot be insured as required in the *Danish Merchant Shipping Act*. If insurance is not to be found, unmanned ships will not be allowed to be put into service. Underwriters are dependent on the approval of unmanned ships by the flag states and the classification societies, and if the ships are not compliant with applicable legislation or possible equal arrangements such approval will be an impossibility.

In continuation, this thesis concludes that unmanned ships will face challenges in meeting the requirements to seaworthiness as requested by the insurance industry. The industry is torn when it comes to whether a ship is seaworthy without a crew or not, yet the majority agrees upon that unmanned ships in general will find it difficult to comply with the legal requirements for seaworthiness.

The final conclusion is that although the law can be interpreted to allow for unmanned shipping, it is written on the premise that personnel is onboard. Therefore, the law needs to be revised before it can be evidently clarified whether unmanned ship operation is a legal option. This is the primary legal challenge of unmanned shipping.

13. PERSPECTIVATION

Through the above discussion of the legal challenges, this thesis has found that many of the concepts included in the international legislation are not defined with sufficient accuracy. As the concepts are interpreted differently between many of our participating associates, a precise definition of concepts such as *manning* and *master* etc. will be crucial to clearly understand how the concepts are to be understood and thus analysed. It is currently unclear who would be to formulate such a clarification process, and whether it will be possible to reach a consensus on the definitions at international level or not.

Additionally, there are different opinions about the possibility of transferring the role of the master ashore. This is because it is not entirely obvious what a master is doing in legal and practice terms on board. In continuation, disagreement can also be found within the industry as to whether a safe navigational watch can be kept away from the ship, primarily due to the unclarity of what exactly a navigational officer is doing on his watch. A deeper analysis would therefore be ideal to accurately clarify what the roles of the navigational officer and the master are at sea as well as what exactly is required of safe watchkeeping in practice.

This thesis is limited to focus on general legal challenges in the operation of unmanned shipping solely, and a closer examination of cargo specific requirements for the different types of cargo ships, their crews and their operations may possibly highlight further legal challenges.

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ANNEXURE

Annex 1: Interessent liste

Annex 2: Ringbom, H. M. (17. februar 2017). Henrik Mikael Ringbom e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 3: Stevens, F. (2. marts 2017). Frank Stevens e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 4: Jessen, H. (2. marts 2017). Henning Jessen e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 5: Berger, T. (28. februar 2017). Tilo Berger e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 6: Jonathan Hare, M. B. (18. februar 2017). Jonathan Hare & Morten Bjerregaard e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 7: Hammer, H. (1. marts 2017). Helle Hammer e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 8: Belcher, P. (17. februar 2017). Philip Belcher e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 9: DNV-GL. (22. februar 2017). DNV-GL e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 10: Questionnaire

Annex 11: Hilduberg, Ø. J. (18. februar 2017). Øssur Jarleivson Hilduberg e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 12: Bertram, V. (18. februar 2017). Volker Bertram e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)

Annex 13: Bardot, A. (18. februar 2017). Andrew Bardot e-mail interview (transkript). (A. H. Larsen & K. Kloch. K. Kloch as interviewer)