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Legal Challenges for Unmanned Ships in International Law of the Sea

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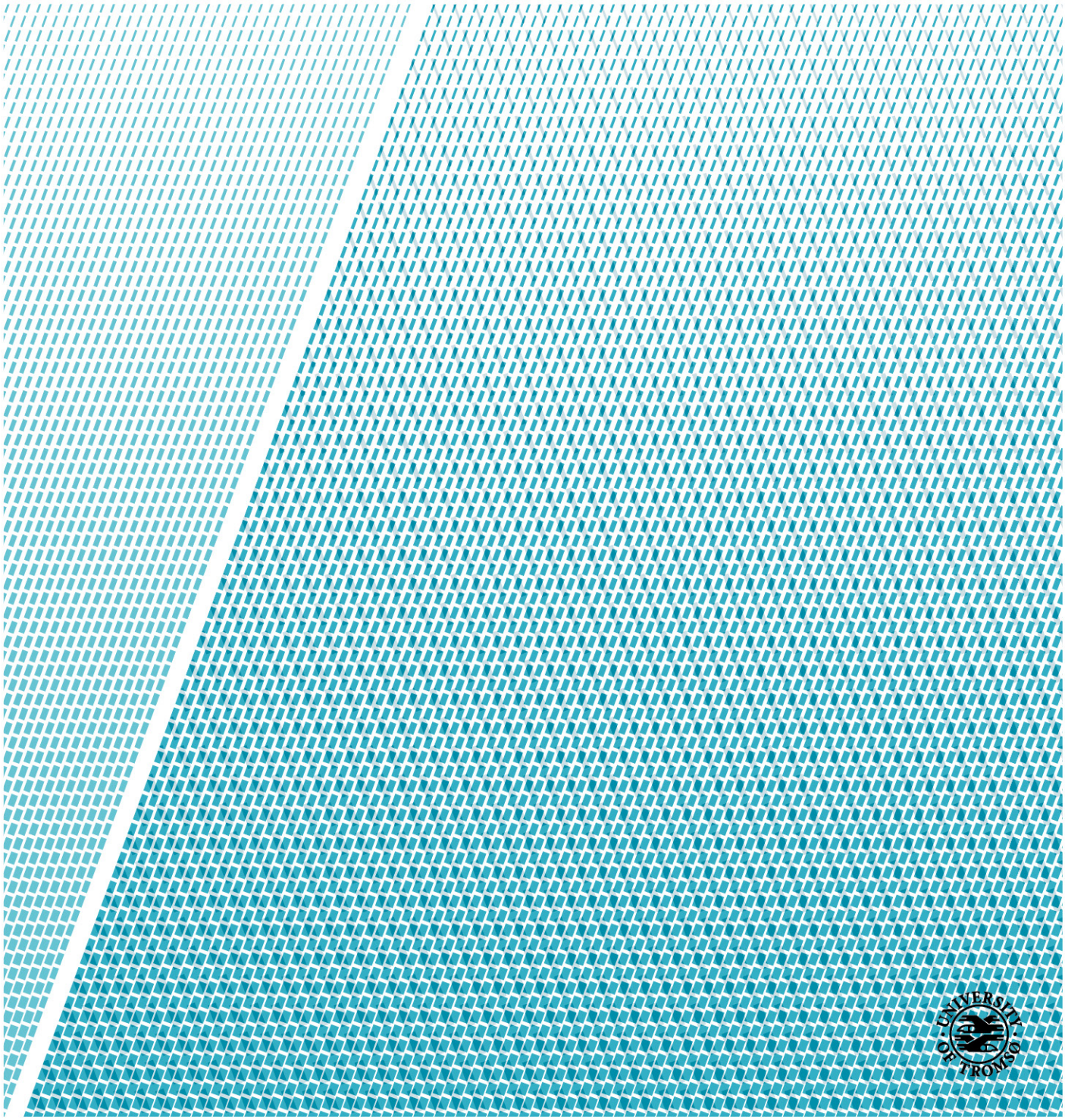

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Abbreviations

AI	Artificial Intelligence
AL	Autonomy Level
CDEM	Construction, Design, Equipment, Manning-Standards
CLC	Convention on Civil Liability for Oil Pollution Damage
CMI	Comitè Maritime International
COLREG	International Regulations for Preventing Collisions at Sea
GAIRS	Generally Accepted International Rules and Standards
HNS	Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea
IMO	International Maritime Organization
IWG	International Working Group
ICJ	Statutes for the International Court of Justice
ITLOS	International Tribunal for the Law of the Sea
LOSC	United Nations Convention on the Law of the Sea
MASS	Maritime Autonomous Surface Ships
MARPOL	Convention for the Prevention of Pollution from Ships
MLA	Maritime Law Associations
MSC	Maritime Safety Committee
MoU	Memorandum of Understanding
OOW	Officer of the Watch
SBO	Shore Based Operator
SCC	Shore Control Centre
SBCC	Shore Based Control Centre
SOLAS	Convention for the Safety of Life at Sea
STCW	Convention on Standards of Training, Certification and Watchkeeping for Seafarers
UNCLOS	United Nations Convention on the Law of the Sea
USV	Unmanned Surface Vehicles
VCLT	Vienna Convention on the Law of Treaties

1 Introduction

1.1 Background and purpose

As a result of the modern technological developments of our time, remotely controlled and autonomous vessels will soon become a reality, leading to major challenges for the legal framework to adapt. Kongsberg Gruppen in collaboration with Yara will have the world's first fully electric and autonomous container ship with zero emissions operating along the coast of Norway within 2020. Other companies are following, as the International Maritime Organization (IMO) have started discussions on Maritime Autonomous Surface Ships (MASS)[1] to understand the magnitude of the issue, and how these may be addressed in IMO instruments.

The transition to this new era of unmanned shipping challenges more than the technology. Unmanned vessels will have to find its place in the existing international legal framework, a framework that currently assumes the presence of an onboard crew.

This thesis looks into the question as to what degree shipowners of unmanned ships can comply with the current regulatory framework, and as part of this determine applicability of the framework. With a focus on bridge-crew, two larger questions are attempted answered: (1) To what degree can certain bridge crew functions be transferred to shore, and (2) to what extent can the current technology replace the bridge crew in the decision-making process.

One may ask why one should move away from the finely-tuned manned shipping that fits so well into the well-armed regulatory framework we currently have, but the benefits of moving from ordinary ships to autonomous or remotely controlled ships are many. As described by Oskar Levander,[2] engineer at Rolls Royce which is one of the world leader's on this new technology, such ships are expected to be 'safer, more efficient and cheaper to run'. Threat by piracy will be less, as the ships design makes them harder to board, and the absence of crew makes hostage and ransom situations unlikely. Moreover, as there is no crew, deck house, crew quarters and ventilation, heating and sewage systems can be held to a minimum, allowing for larger cargo capacity and lower wind resistance pursuant to Levander.[3] This will

[1] For more information on this project, see IMO 'IMO takes first step to address autonomous ships' <http://www.imo.org/en/mediacentre/pressbriefings/pages/08-msc-99-mass-scoping.aspx>
[2] Levander, Oskar, *Autonomous Ships on the High Seas* (Published in IEEE Spectrum, Volume 54, Issue 2, February 2017), p 28 https://ieeexplore.ieee.org/document/7833502/ accessed 14 June 2018
[3] Levander, (2017), p 28

make the ship lighter and sleeker 'cutting fuel consumption, reducing operating and constructions costs and facilitating designs with more space for cargo'. The current lack of people with maritime skills that find it attractive to spend weeks away from home and family will be a smaller problem, as more jobs would be move to shore-based positions.[4] The European Maritime Safety Agency point to human error as the triggering factor in 62 per cent of incidents with EU registered ships from 2011 to 2016.[5] Though, the safety of electronically operated devices is not fully established yet and fully autonomous shipping is many years ahead, a decrease in marine casualties, while not guaranteed, is hoped for.

Firstly, an introduction to the unmanned ship and the various levels of autonomy is presented and the importance of autonomy-levels for applying the framework. Throughout the thesis the term *'unmanned'* is used when referring to both remotely controlled and autonomous vessels, but the terms remote or autonomous are used when a distinction is necessary.
In part 3 the thesis examines applicability of the legal framework and moves on to determine the possibility of replacing onboard crew with shore-based controllers or altogether with technology. Lastly, possible solutions to non-compliance are discussed

1.2 Scope and limitation

There is more than one regulatory challenge that needs to be examined in order for unmanned ships to be operable. This thesis will focus on the international public regulations that are unclear about whether unmanned ships are currently permitted. Distinguishing between three main kinds of international regulations the first being (1) jurisdictional rules that lay down rights and obligations of States. These are mainly found in LOSC. (2) The technical rules on safety, environment and training and watchkeeping standards. These are found in various conventions, three of which will be the focus of this thesis. (3) Private regulations regarding liability, insurance, contractual issues and other issues of private character.

This thesis mainly focuses on the two first categories. Private regulations are left out of the scope. While these raise interesting questions, they are too complex and spacious to handle in this thesis as well. Regulatory challenges regarding passenger ships are left out for the same reason, and the emphasis is public rules regulating merchant cargo ships.

[4] Levander, (2017), p 29
[5] M. Blanke, M. Henriques, J. Bang, *A pre-analysis on autonomous ships* (Publication by Danish Maritime Authority and Technical University of Denmark, 2016), https://www.dma.dk/Documents/Publikationer/Autonome%20skibe_DTU_rapport_UK.pdf, p 4, Accessed 29 March 2018

Pursuant to IMO, unmanned shipping will most likely start with partially unmanned ships. The ship is then operated from shore, but certain crew members are still on board to be able to take over manual steering and maintain some of the tasks on the bridge. These ships raise different questions again, as there are still legal subjects to apply the framework to, but not sufficient amount of crew to fulfil the tasks. These questions are not raised in this thesis due to time-considerations.

The IMO has started discussions on MASS[6] to understand the magnitude of the issue, and how these may be addressed in IMO instruments. A working group has performed a scoping exercise on; ships with automated processes and decision support but with seafarers on board, remotely controlled ships with seafarers on board, remotely controlled ships with no seafarers on board that are operated from shore, and fully autonomous ships.
Instruments covered by IMO's Maritime Safety Committees scoping exercise include the 1978 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers(hereinafter STCW), the 1982 United Nations Conventions on the Law of the Sea(hereinafter UNCLOS), the 1974 International Convention for the Safety of Life at Sea, as amended (hereinafter SOLAS) and the 1972 Convention on the International Regulations for Preventing Collisions at Sea, as amended (hereinafter COLREGs), as well as the 1966 International Convention on Load Lines, the 1979 International Convention on Maritime Search and Rescue(SAR), the 1995 International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel(STCW-F), the 1969 International Convention on Tonnage Measurement of Ships as well as certain passenger ship instruments. This thesis will focus on transfer of duties within the first four conventions; STCW, UNCLOS, SOLAS and COLREGs. These are some of the most ratified conventions, and more importantly, they contain specific bridge manning-requirements that are necessary to discuss to determine degree of possible compliance.

The thesis does not attempt to be exhaustive in its account, as the entrance of unmanned ships challenges many provisions in nearly all law of the sea and maritime law conventions. Examination of the transfer of duties are questions of highly complex technical nature. In order to fully determine these issues, it is necessary to build bridges between law and technology. When this thesis attempts to review the legality of possible transfer of functions from crew to shore, and the legality of replacing of human judgement in the decision-making

[6] For more information on this project, see IMO 'IMO takes first step to address autonomous ships' <http://www.imo.org/en/mediacentre/pressbriefings/pages/08-msc-99-mass-scoping.aspx>

process, it is necessary to explain and understand parts of the technology. This is a time-consuming task, and the thesis therefore only attempts to examine a very few select provisions that are crucial to determine whether the framework could tolerate this transfer of crew, or if maybe it is necessary to consider a new framework.

1.3 Sources and methodology

The thesis employs Article 38 of the 1945 Statute for the International Court of Justice (ICJ) to identify sources, as these are 'generally regarded as a complete statement of the sources of international law'[7], whereas the methods for analysing treaties will be in accordance with 1969 Vienna Convention on the Law of Treaties (hereinafter VCLT). A treaty should be interpreted 'in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose', pursuant to Article 31 (1). Together with the context, which is explained in Article 31 (2), there shall be taken into account 'any subsequent practice in application of the treaty which establishes the agreement of the parties regarding its interpretation' cf. Article 31 (3) b).

Recourse may be had to supplementary means of interpretation 'in order to confirm the meaning resulting from the application of Article 31, or to determine the meaning when the interpretation according to Article 31(…)' is left ambiguous or leads to an absurd or unreasonable result, this pursuant to Article 32 of VCLT.

This thesis focuses on the aforementioned conventions, STCW, LOSC, SOLAS and COLREGs, but the entire legal framework for unmanned vessels is currently unforeseen. While the maritime law seems well armed, this also raises the challenge of identifying the problematic conventions and provisions. Applying, interpreting and amending these to suit the various types of unmanned ships imaginable is yet another challenge. Depending on the level of automation, different challenges arise.

As the legal sources available are all written in an era long prior to unmanned vessels being even contemplated, this raises the discussion as to the weight of the wording of the existing conventions. The VCLT seems to favour an objective interpretation of the wordings,[8] as opposed to a subjective interpretation where the intent of the parties is added weight to.

[7] I Brownlie, *Principles of Public International Law* (OUP Great Britain, 8th ed, 2012) p 20
[8] Robert Kolb, *The Law of Treaties: An Introduction* (Edward Elgar Publishing, 2016), Chapter VII Interpretati

The parties at the time of writing could not have intended to apply the legal framework to autonomous ships, the provisions in question are old and the technological development unforeseen. Engaging in a discussion where the intent is heavily weighted will therefore leave the provision interpreted stricter than what might be advantageous.
Since LOSC in particular is a result of many compromises, reservations and trade-offs, the wording of the provisions has even more weight as they are very carefully chosen, leaving the object and purpose slightly secondary. Engaging in a very restrictive or liberal interpretation of the provisions need therefore be done with caution and sought balanced with other values and constraints. Exercising caution with full realisation of the intention is expressed amongst other by Robert Kolb in his The Law of Treaties: An introduction.[9] Still, intent may be subsumed under the 'object and purpose'-test in Article 31 (1) in its subjective meaning.[10]

When this thesis examines a theme which is relatively new, and there is little jurisprudence and limited literature, the narrow picture of available sources become even more important. So that while the 'common intent' of the parties is not necessarily weighted heavily, the lack of other sources more often than not makes it necessary to interpret this into the discussions of this thesis and might make it necessary also to weigh in also the supplementary means in Article 32 of VCLT more frequently.
Certain provisions from the 1982 United Nations Conventions on the Law of the Sea is examined in this thesis with a view of applying these to unmanned ships. While the other conventions used here are IMO-conventions and subject to change, the LOSC has not been amended since its conclusion in 1982. Two supplementary agreements have entered into force after its conclusion, but these are not relevant when it comes to unmanned ships. As such, the LOSC as it stands now is the same as 30 years ago. This emphasises the necessity of not using subjective means in a too expansive manner. Conventions are made to last and interpreting them in line with the intentions almost 40 years later does not allow for much adaptation to the political, social and legal surroundings. Many parties have acceded to the agreement later too, and the common intent at the time of conclusion might not be shared by these. However, where the intent is clear and known, and still a viable intent, and supposing that the text is less clear, this is weighted in this thesis to support the limited source situations.

[9] Kolb, 2016, p 146
[10] Kolb, 2016, p 133

While Article 38 of ICJ refers to international jurisprudence[11], a limited amount of this is applied in the thesis. As unmanned vessels are currently not in operation, the amount of jurisprudence in the area is thus non-existent. This also greatly limits the amount of customary law.[12]

To supplement this slightly limited source-situation, working papers from IMOs Maritime Safety Committees working group on MASS is used. Specifically IMO's questionnaire in MSC 99/INF.8[13] as submitted by the Comitè Maritime International (CMI) and the answers submitted to CMI here by 19 Maritime Law Associations from various countries around the world on their suggested interpretation of the international framework is used to suggest interpretations of the conventions, and to examine how States can be expected accept different interpretations of problematic provisions. Also, the MSC 99/5/6, as submitted by Finland on considerations on definitions for levels and concepts of autonomy as submitted by Finland is used.[14]

The European Commission project MUNIN,[15] funded by EU, and their results from developing a technical concept for the operation of an unmanned merchants ship and assessing the technical, economic and legal feasibility is also used, particularly the 7.2 Deliverable on Legal and Liability Analysis for Remote Controlled Vessels.[16]

The Advanced Autonomous Waterborne Applications Initiative[17](AAWA) is a project funded by the Finnish Funding Agency for Technology and Innovation, combining the expertise of some of Finland's top academic researchers and leading members of the maritime cluster including Rolls-Royce, DNV-GL, Inmarsat, Deltamarin, NAPA, Brighthouse Intelligence, Finferries and ESL Shipping. Their description of possible functioning of an unmanned ship is used to illustrate here. A legal analysis has been made and is referred to throughout the thesis.

Articles and literature from various scholars that have sought to interpret the legal framework also account for a wide portion of the sources used in this thesis.

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[11] ICJ Article 38 (1) d)
[12] ICJ Article 38 (1) b)
[13] IMO MSC 99/INF.8 Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS), Submitted by CMI, 13 February 2018
[14] MSC 99/5/6, 12 March 2018 Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS) - Considerations on definitions for levels and concepts of autonomy, Submitted by Finland
[15] MUNIN Research Project, http://www.unmanned-ship.org/munin/wp-content/uploads/2016/02/MUNIN-final-brochure.pdf
[16] MUNIN Deliverable 7.2: Legal and Liability Analysis for Remote Controlled Vessels, 2013.
[17] AAWA 2016 Position Paper, *Remote and Autonomous Ships: The Next Steps* by Rolls Royce (London 2016)

2 What is an unmanned ship – An introduction

The aim of this chapter is to present the reader with basic knowledge of what an unmanned ship may look like and the importance and relevance of the different levels of autonomy when discussing the legal aspects of unmanned shipping, without going into depth on the technical details. An important distinction between manning and levels of autonomy will be made. Finally, various levels of autonomy is discussed and which levels this thesis focuses on.

2.1 Theoretical functioning of an unmanned ship

Unmanned ships are ships navigating on water in absence of onboard crew and has this as his primary mode of operation. The ship is then either (1) remotely controlled via computer by a shore-based operator, or (2) the ship is autonomous, a pre-programmed ship operating solely on artificial intelligence to reach the predetermined nautical course. (3) The ship may vary between these two modes of operation during a journey. All levels of autonomy are presented in Part 2.2.

In the following, an explanation of how an unmanned ship may function in reality is attempted, as suggested by the AAWA 2016 Position Paper.[18] The AAWA project contains a thorough example of a general cargo vessel operating between two ports through different levels of autonomy by one human operator, which illustrates how operating remotely or autonomous most likely will look like.

2.1.1 AAWA's unmanned ship

For some time forward, the 'unmanned' ships will be *partly manned* for a streamlined transition towards completely unmanned shipping. Moving towards unmanned shipping, remote controlled operation is the primary mode of functioning, at least for the foreseeable future. The ship may be completely autonomous for parts of the voyage, particularly on the deep sea, but in congested and/or narrow fairway, under harsh weather conditions or when mooring and unmooring the remote controller will be controlling or monitoring at all times. In the future, AAWA Position Paper anticipates that the ship will become self-learning and operated by artificial intelligence.[19] This will remove the human in loop all together. 'As the control algorithms will evolve and mature over time, the ships will be capable of handling increasingly complex situations on her own.[20]

[18] AAWA 2016 Position Paper
[19] AAWA 2016 Position Paper, p 7
[20] AAWA 2016 Position Paper, p 11

In order for this to fully function, there are certain issues that have to be taken into account by the operator. Pre-voyage, each leg[21] of the voyage is predetermined, and which legs will be autonomous or remotely controlled. Using various satellite and land-based communications networks, a remote controller should be able to operate an unmanned vessel regardless of location and mode. For the case that this is lost, AAWA suggest fallback strategies for each leg. These strategies could include taking manual control, slow down and proceed to next waypoint, or return to previous waypoint, maintaining DP mode[22], or navigate back to a pre-set safe location.[23] Veal and Ringbom[24] suggests also that COLREGs Rule 18 is employed if there is a loss of communications. Rule 18 on 'Responsibilities between vessels' gives navigational priority to 'vessels not under command'. This will be examined more thoroughly in part 3.5.

In mooring and unmooring the vessel may by fully or semi-automatic, depending on shore-based crew to secure the docking, and dockside infrastructure, as well as possible pilot-requirements of the port. When unmooring, shore-based crew is necessary to securing cargo.

In normal operational mode, such as at open sea, the planned mission from waypoint to waypoint is anticipated performed in autonomous mode. Meanwhile the shore control centre can monitor and operate multiple vessels simultaneously. Operator-interaction is requested by the system should the autonomous navigation system decision-making threshold be exceeded, due to the original plan needing adjustments for some unexpected reason. The requested level of interaction will be adjusted to the scenario. I.e. a vessel deviating slightly from planned course to stay out of way of another vessel but staying within set limits will give the operator warning, and chance to manually control for a limited time. A warning also gives the operator chance to communicate with the other vessel, informing it and confirming the action taken is safe for both parties.
Should a complete leg need re-planning, options are offered and the operator confirmation to choose route is requested. For more complex scenarios where the artificial intelligence of the system is incapable of solving the situation, an immediate warning is sent to the operator. Is user response not received, a set of fallback strategies is ready to be executed, depending on the urgency of the situation.

[21] A leg is a planned route of the vessel between two waypoints
[22] DP mode or Dynamic Positioning is a system that maintain the ships position by pinpointing wind and wave data which would otherwise make the ship loose its position, without the use of anchors
[23] Fallback strategies as suggested by AAWA 2016 Position Paper, p 8
[24] R Veal, H Ringbom, *Unmanned ships and the international regulatory framework* (The Journal of International Maritime Law, 2017), p 111

As already mentioned, the IMO project that the era of unmanned shipping will start with partly manned ships, and then move on to remotely controlled ships. It is preferable to perform parts of the voyage in autonomous mode in due time, but first the legality of these modes of operation needs to be examined.

2.2 Levels of autonomy

The IMO via its MSC Working Group is currently working on definitions of levels of autonomy of unmanned vessels. MSC 99/5/6 as proposed by Finland.[25] stated that; in any case, the current suggestions on levels of autonomy as proposed by various organisations prior to the meeting, must be 'tested and validated in real projects to ensure their practical applicability'[26]. A clear definition of the autonomy levels is thus still a few years ahead, and while there are several good proposals by the industry, one has yet to be universally accepted.

In the following, a presentation of suggested levels of autonomy will be made. Firstly, it is necessary to make a distinction between autonomy and manning. The currently manned ships at sea are partially automatic and autonomous even today. Different means of technology are used by the bridge team on board the ship that to some degree runs the ship, without interference of the bridge team, but they continuously monitor it and may make changes to the proposed actions. This illustrates how a ship may be autonomous but still manned. In this thesis, the ship is no longer manned. It is controlled remotely but still utilises the same technology to suggest actions that the shore-based operator approves of, as illustrated above.

2.2.1 Suggestions on levels of autonomy

Finland collected various definitions from several organisations on levels of autonomy to MSC99/5/6, amongst them two classification societies, two industry/research associations, a consulting firm and one by companies offering autonomous technologies. While many of the suggestions have looked at the automotive industry and their recently agreed joint view of autonomy levels in cars, Finland in MSC 99/5/6 highlights that the marine industry faces greater difficulties, as it is not enough to only consider navigational autonomy. A ship has a wide range of systems operating on board and the levels of autonomy must be applicable to all these systems. Once the ship has left shore, manual override is only possible from ashore. As opposed to cars, any errors in any of the functionalities of the ship must be handled by the remotely controlled systems operated from ashore, without manual human action. One cannot

[25] IMO MSC 99/5/6
[26] IMO MSC 99/5/6, p 5

simply stop the ship to fix whatever is wrong when the ship is in the midst of the high seas, it could take days to reach the ship. These challenges differ from what the automotive industry meets.
The suggestions in MSC 99/5/6 vary from four to six levels, and the content in the suggested levels vary. It seems to be agreed that the lowest level is 'in general a level where the human is in charge, whereas the highest level is one where the ship operates unassisted on its own'[27].

Moving from manually controlled vessels to fully autonomous ships is a scale of delegating decision-making to the system. In MSC 99/5/6 when moving from fully manual operation, the next level appears to be where decision support may suggest actions in certain areas where the crew on bridge confirms these. The next level seems to be where the system suggests all actions, while the operator confirms or rejects. The operator may be shore-based at this point. The final levels are where the system operates on its own, but the operator is informed of all decisions and actions, in cases where the calculations of the systems interpretation of its surroundings and condition are uncertain the operator has final call. Finally, the system operates fully on its own, the ship is pre-programmed to set nautical course without any human interaction. This may be combined with using artificial intelligence. The vessel then becomes more self-guided and process the data from radar, camera, satellite-images on her own to make navigational decisions. All tasks are taken over by the systems. It only informs the operator in case of an emergency. There may be levels between these, as some of the suggestions contain. It is noted that DTU submits that 'it has been expressed that total autonomy is not necessarily the most appropriate or best economic solution for all types of surface vessels'[28]. Without going into the desirability of fully unmanned ships, this thesis notes that moving towards total autonomy is not necessarily the goal. That should be kept in mind when deciding on means to address unmanned ships in the legal framework.

Lloyds Register summarised terminology in their Cyber-Enabled ships Ship Right Procedure in July 2017 suggest seven levels of autonomy (ALs). The Danish Maritime Authority has adapted Lloyds Register's table of ALs to a more understandable language for non-engineers:[29]

[27] IMO MSC 99/5/6, p 5
[28] Blanke, et al (2016), p 5
[29] Blanke, et al (2016), p 6

Table 2. Autonomy levels (AL) adapted from Lloyds Register by the Danish Maritime Authority[30]

Description	Operator role
AL 0: Manual steering. Steering controls or set points for course, etc. are operated manually.	The operator is on board or performs remote control via radio link.
AL 1: Decision-support on board. Automatic steering of course and speed in accordance with the references and route plan given. The course and speed are measured by sensors on board.	The operator inserts the route in the form of 'waypoints' and the desired speed. The operator monitors and changes the course and speed, if necessary.
AL 2: On-board or shore-based decision support. Steering of route through a sequence of desired positions. The route is calculated so as to observe a wanted plan. An external system is capable of uploading a new route plan.	Monitoring operation and surroundings. Changing course and speed if a situation necessitates this. Proposals for interventions can be given by algorithms.
AL 3: Execution with human being who monitors and approves. Navigation decisions are proposed by the system based on sensor information from the vessel and its surroundings.	Monitoring the system's function and approving actions before they are executed.
AL 4: Execution with human being who monitors and can intervene. Decisions on navigation and operational actions are calculated by the system which executes what has been calculated according to the operator's approval.	An operator monitors the system's functioning and intervenes if considered necessary. Monitoring can be shore-based.
AL 5: Monitored autonomy. Overall decisions on navigation and operation are calculated by the system. The consequences and risks are countered insofar as possible. Sensors detect relevant elements in the surroundings and the system interprets the situation. The system calculates its own actions and performs these. The operator is contacted in case of uncertainty about the interpretation of the situation.	The system executes the actions calculated by itself. The operator is contacted unless the system is very certain of its interpretation of the surroundings and of its own condition and of the thus calculated actions. Overall goals have been determined by an operator. Monitoring may be shore-based.
AL 6: Full autonomy. Overall decisions on navigation and operation are calculated by the system. Consequences and risks are calculated. The system acts based on its analyses and calculations of its own capability and the surroundings' reaction. Knowledge about the surroundings and previous and typical events are included at a 'machine intelligent' level.	The system makes its own decisions and decides on its own actions. Calculations of own capability and prediction of surrounding traffic's expected reaction. The operator is involved in decisions if the system is uncertain. Overall goals may have been established by the system. Shore-based monitoring.

Prior to more unmanned ships coming into operation, agreeing on final, universally accepted autonomy levels for the marine sector is not expected. Understanding the variations on levels

[30] Blanke, et al (2016), p 6

of autonomy is still crucial in order to apply the legal framework onto the various degrees of unmanned ships to identify where the legal challenges arise, as we will see in the next chapter.

2.2.2 Legal relevance

We have now seen what remotely controlled and autonomous ships are. In the following, a quick view of the legal challenges that arise and how these can be quite different depending on the level of autonomy of these ships will be attempted.

This thesis will focus on the autonomy levels approximately between 3-6, depending on definitions. At this point the ship is crewless, the operator is either shore-based and remotely controls or remotely supervises the ship, or the ship is pre-programmed and might also utilise artificial intelligence.

When it comes to applying the legal framework to completely unmanned vessels, the level of autonomy is of importance. Particularly between the remotely controlled unmanned vessels operated by an SBO and the autonomous ships operating without any human supervision. The first still has a human in loop, but the second has replaced the human with technology in the decision-making process. The regulations that this thesis look into, LOSC, STCW, SOLAS and COLREGs all seem to base themselves on a human being in the loop. To what degree this is the case is the subject of examination in the next chapter.

Fully unmanned ships thus seemingly raise more questions than remotely controlled. For the case of remotely controlled ships, it might be possible to transfer many of the duties upon the crew to the shore-based control centre (SBCC), and the ‘crew’ there, still leaving someone to apply the framework to, and most likely this requires a much smaller intervention into the legal system, as we will see in the next chapters.
When the ship is fully autonomous and pre-programmed, there is a lack of legal subject to impose the requirements on. The consequences and solutions to this will be debated later on.

3 Challenges with the current legal framework

3.1 Introduction

The aim of this chapter is to determine to what degree the framework is applicable, and if so, to what degree the functions of the bridge crew can be transferred to the SBO, and second, to which extent the framework allows for human judgement to be replaced by technology in the decision-making process, focusing on the same bridge crew positions. As previously mentioned, the examined conventions are SOLAS, LOSC, COLREG and STCW and the provisions these contain that requires specific bridge crew positions.

A bridge team usually consist of a master, an officer of the watch (OOW), a sailor as helmsman and a lookout, but often additional crew joins the bridge team as well. This thesis takes a closer look at the duties of the master, the lookout and the OOW. The duties of the helmsman have seemingly not been problematised by academia. This thesis has chosen not to look into the transfer of duties of the helmsman. Partly as it seems not to raise any questions, and partly as it would require technical insight if one were review the transfer of such a function, that the author is not in possession of. Some regards the pilot as part of the bridge team as well. He is also left out of the scope of this thesis, as pilotage in general is regulated by private conventions, and they raise many interesting questions that this thesis does not have time or space to examine.

The regulations for the functions that are to be examined are found in four different public conventions. LOSC regulates the requirement of a master on board the ship. In COLREG and STCW the requirement of a lookout and an OOW are found. SOLAS contains the provision regarding the safe manning a ship altogether, and this is used as a starting point for discussing whether the transfer of these other duties is possible in a safety at sea-perspective.

Should the duties not be possible to transfer, compliance for unmanned ships to the framework the way it looks now is impossible. This would lead to the entirety of the legal framework requiring adaptation or an entirely new framework coming together *prior* to unmanned ships coming into operation - a comprehensive work that will take years to finish and possibly putting a brake on the technological innovations, and that is why this thesis aims to examine the possibility of transfer of these functions, before discussing amendments. First, an introduction of the four select conventions will be presented.

3.1.1 The legal framework

The United Nations Conventions on the Law of the Sea (LOSC) also referred to as 'the constitution of the oceans' has 168 ratifications and is widely accepted as representing customary law. LOSC deals with the rights and obligations of States over the seas. As far as shipping is concerned, the primary issues in this convention is to which degree ships can navigate in the different sea areas, the obligations of flag States over their registered ships, as well as other States right to interfere in the navigation of ships.

The 1974 International Convention for Safety of Life at Sea (SOLAS) with 164 contracting parties[31], representing about 99% of world tonnage, obliges contracting States to ensure minimum standards on construction and seaworthiness to ensure the safety of life at sea. While SOLAS presents various difficulties when moving towards unmanned ships, one of the principal areas is ensuring the safety of navigation, and this will also be the starting point for the examination done in this thesis. SOLAS applies to "ships entitled to fly the flag of States the Governments of which are Contracting Governments", meaning State Parties to SOLAS. It prescribes no general definition of ship, so long as they are "cargo ships of less than 500 gross tonnage"[32] engaged in "international voyage"[33].

The 1972 International Regulations for Preventing Collisions at Sea (COLREG) is made to prevent collisions at sea, and has 169 contracting parties, representing about 99% of world tonnage. The COLREGs apply to "all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels"[34]. Vessels for these purposes include "every description of water craft (…) used or capable of being used as a means of transportation on water"[35]. The fundamental objectives of COLREG are establishing collision avoidance standards, safety of life and property at sea and establishing navigational standards and avoid risk of collisions[36]

The 1978 Convention on Standards of Certification, Training and Watchkeeping for Seafarers, as amended has 164 contracting parties, representing about 99% of world

[31] IMO Official Numbers on Status of Treaties, see http://www.imo.org/en/About/Conventions/StatusOfConventions/Documents/StatusOfTreaties.pdf, accessed 5 August 2018
[32] SOLAS Annex, Chapter 1, Reg. 3 (a) (ii)
[33] SOLAS Annex, Chapter 1, Reg. 1 (a) cf. Reg. 2 (d)
[34] COLREG Part A, Rule 1 (a)
[35] COLREG Part A, Rule 3 (a)
[36] MUNIN Deliverable 7.2 (2013), p 12-13

tonnage[37]. The convention aims to promote life, property and the environment at sea by establishing international norms for training, certification and watchkeeping. STCW applies to 'seafarers serving on board seagoing ships (…)'[38] and flying the flag of a State party, seemingly not applying to unmanned ships cf. the 'on board'-requirement. This will be more closely examined later.

3.2 Applicability of the legal framework to unmanned ships

In the previous Chapter 3.1 the applicability of the four conventions were established to apply to various types of 'ships'. This does not on its head mean that they apply to *unmanned* ships. The first and fundamental question is therefore: Are unmanned vessels in fact 'ships' or 'vessels' at all? When the international regulatory framework applies to *ships*, it is therefore necessary to establish unmanned ships as ships so that the rights and obligations placed upon flag States applies also to a State's registered unmanned ships. Should the answer to this be negative, the conclusion is that the law of sea and all its problematic provisions finds no applicability to unmanned ships at all, thus dodging all the issues it raised, but also dodging all the safety measures and values that these conventions are made to protect. This part will start with an examination of the term 'ship' to determine applicability of the law of the sea.

SOLAS, STCW, COLREGs and UNCLOS are all conventions drafted with manned vessels in mind. When removing the crew, many of the requirements imposed on the crew no longer have a legal subject. This entails three possible solutions. (1) Unmanned vessels are non-compliant and hence illegal to operate. (2) The duties do not have any legal subject to apply themselves to, and unmanned vessels are legal based on the mere fact that the entirety of framework does not apply to them. (3) And more likely, the duties are applicable, but they need to be transferred to shore-based personnel, and they must fulfil the requirements instead of the onboard crew.

3.2.1 Are unmanned ships 'ships'?

The term 'ship' and 'vessel' appears in various provisions in LOSC and the IMO Conventions and they are used interchangeably. But the term is never strictly defined, leaving to interpretation to determine what its legal content is. For the instruments that do contain a definition, a wide variety of choices are available.

[37] IMO Official Numbers on Status of Treaties
[38] STCW Article III

With regards to LOSC, Article 91 states that; 'every State shall fix the conditions for the grant of its nationality to ships'. A natural understanding of the wording suggests that whether or not an unmanned ship is also a "ship" depends on the laws of the flag State and how these define a 'ship'. SOLAS and STCW applies to all ships entitled to fly the flag of States the Governments of which are contracting parties, indicating the same. COLREGs considers a 'vessel' to be 'every description of water craft […] used or capable of being used as a means of transportation on water', and hence do not seem to pose any particular issues for unmanned ships. In the following, a discussion on what national and international law on what constitutes a ship is discussed.

At the national level, it seems the definition of a ship is disconnected from the question of whether or not the ship is manned as well, and thus whether the ship is manned or not should not be of relevance to its definition, allowing unmanned ships to be subsumed under the current the term. Per the examination by Eric Van Hooydonk; The UKs Merchant Shipping Act, Section 313 (1) provides that the "ship" includes "every description of vessel used in navigation". The Dutch Civil Code in the same way, understands ships to be all things "that are not an aircraft, which pursuant to their construction are intended for flotation and which float or have floated"[39]. In the US, the word "vessel" includes "every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water"[40]. The Maritime Code of the Peoples Republic of China[41] and Spain's 2014 Navigation Act[42] both go in the same direction – referring to size and functions, but not to manning. It seems clear that at the national level, determining what is a "ship" is not connected to whether the ship carries on-board personnel.

In CMIs questionnaire on unmanned ships[43], 17[44] of the 19[45] asked maritime law association of each country answered that an unmanned ship would or most likely would constitute a ship under national law. The two remaining countries, Panama and Croatia answered that either an unmanned ship would not on its head be considered seaworthy, pursuant to Croatia, and

[39] Dutch Civil Code, Book 8, Article 8:1.1, per the examination and reference of Hooydonk, (2014), p 408
[40] The Code of Law of the United States §3, per the examination and reference of Hooydonk, (2014), p 408
[41] The Maritime Code of the Peoples Republic of China, Article 3, para 1, per the examination and reference of Hooydonk, (2014), p 408
[42] Spain's 2014 Navigation Act, Article 56, per the examination and reference of Hooydonk, (2014), p 408
[43] IMO Committee MSC 99/INF.8, Annex 1, p 1
[44] The Argentian, Canadian, Dutch, Irish, Japanese, Maltese, Singaporean, US, Brazilian, British, Chinese, Danish, Finnish, French, German and Spanish MLAs
[45] The Argentinian, Brazilian, British, Canadian, Chinese, Croatian, Danish, Dutch, Finnish, French, German, Irish, Italian, Japanese, Maltese, Panamian, Singaporean, Spanish and US MLA's were the 19 responders of CMI's questionnaire

Panama answered that it would be up to the Administration to decide on a case by case basis what is a ship. 13[46] of the 17 MLAs that answered that an unmanned ship could constitute a ship under their national law also replied either directly or indirectly that manning is no express criterion for registration, underlining the above argumentation that manning is disconnected from the definition of the ship.

The definition of a ship is disconnected from manning-requirements also in international conventions that define ships. Numerous public maritime law conventions apply their own definitions tailored to the matter at hand. For instance, the London Dumping Convention[47] where the phrase 'vessels and aircraft' means 'waterborne or airborne craft of any type whatsoever'. In the same direction goes MARPPOL Article 2 (4); 'A ship means a vessel of any type whatsoever operating in the marine environment (…)'[48]. The 1992 CLC describes a 'ship' as 'any sea-going vessel and seaborne craft of any type whatsoever constructed or adapted for the carriage of oil in bulk as cargo (…)'[49]. As already mentioned, COLREG's considers a 'vessel' to be 'every description of water craft […] used or capable of being used as a means of transportation on water'[50]. The HNS Convention[51] and the Bunker Convention[52] have similar wordings, not linking manning to the definition of what constitutes a ship. On the other hand, these conventions did not need to address manning. At their point of conclusion, it was obvious that there would be crew on the ship, and unimaginable that it would not be.

Still, while there is no general definition of what constitutes a ship, it seems that national as well as international law would not consider an unmanned vessel not to constitute a ship, at least not on the sole criteria that it is not manned.

Unmanned ships classifying as 'ships' within the meaning of the law of the sea seems to be the general perception amongst academics as well. As stated by Hooydonk with reference to J

[46] British, Canadian, Chinese, Danish, Dutch, Finnish, French, German, Irish, Italian, Japanese, US MLAs.
[47] The 1972 Convention on the Prevention of Marine Pollution by Dumping of Waster and Other Matter, as amended
[48] The International Convention for the Prevention of Pollution from Ships
[49] The 1992 International Convention on Civil Liability for Oil Pollution Damage as amended, Article 1.1
[50] COLREG Rule 3 (a)
[51] The 1996 International Convention on Liability and Compensation for Damage in connection with the Carriage of Hazardous and Noxious Substances by Sea, Article 1 (1)
[52] The 2001 International Convention on Civil Liability for Bunker Oil Pollution Damage, Article 1.1

Kraska 'most commentators rightly assume that for the purpose of the law of the sea unmanned vessels must be regarded as ships'[53].

Veal and Ringbom[54] also points out that similarities between the functions are an argument in direction of interpreting unmanned vessels as 'ship'. It follows from the nature of the activities of merchant shipping vessels, manned or unmanned that by virtue of their size, feature and functions, which are exactly the same for manned and unmanned, that also unmanned vessels should be regarded as vessels or ships in the meaning of LOSC. It would 'seem unjustified that two ships, one manned and the other unmanned, doing similar tasks involving similar dangers would not be subject to the same rules which have been designed to address those dangers'[55].

Considering the aforementioned arguments, it may be concluded with a considerable degree of certainty that onboard crew is not a requirement for considering an unmanned ship to be a 'ship' indeed. Presumably this leaves the regulatory situation reasonably straight forward: 'the starting point is that the unmanned ships are subject to the same rights and obligations as their manned counterparts'[56].

3.2.2 Applicability of STCW

The STCW contains another requirement in addition to 'ship'. Pursuant to its Article III; it applies to "seafarers serving on board seagoing ships (…) and flying the flag of a State party'[57]. A strict interpretation of the wording 'on board' suggest that this convention prima facie finds no application to unmanned ships – the crew is not 'on board'. However, it seems academia is undecided on how to interpret this.

Taking into consideration that the objective and purpose of the convention is ensure the safety of life and property at sea, and protect the marine environment[58], it seems just to expand application to shore based personnel. Even though the crew is no longer on board, there is still life, property (cargo) and environment to protect from an accident or collision, suggesting that the convention should be to applied to the shore-based crew.
Also, considering that the STCW Convention under Article IX (1) allows an administration to

[53] E Hooydonk (2014), p 406 with reference to J Kraska *The Law of Unmanned Naval Systems in War and Peace* (The Journal of Ocean Technology 44, 2010), pages 51-53
[54] Veal, Ringbom (2017), p 102
[55] Veal, Ringbom (2017), p 102
[56] AAWA 2016 Position Paper, p 54
[57] STCW Article III
[58] STCW Preamble

'adopt other educational and training arrangements (…) especially adapted to technical developments and special types of ships (…)', allowing for technical innovations to fit into the existing framework is not unreasonable.

The AAWA Position Paper argues that even though the crew is now situated at shore, their necessary maritime and technology skills still needs to be considered, and that in the meantime, it is 'probably safer to apply (at least) the STCW and other national requirements analogically (as if the persons were on board the ship)', but that it would need amendment if and when one agrees on the particular training needed for unmanned operations.[59] This is supported by L Carey, which argues that given the purpose of the convention, it is 'foreseeable that the Convention will be expanded to apply to shore-based personnel'[60], thus suggesting that an amendment will be necessary to apply STCW, and not only analogical application. The MUNIN project also suggests adjusting the STCW to make it capable to apply to shore-based operators, and the specific requirements upon their training that is necessary.[61]

The Danish and Finnish Maritime Law Associations has not ruled out that shore-based crew could be considered crew under their national law, even though both countries require the crew to be on board. They go a long way in suggest that as long as the result of the performance takes place on board, where the function is actually performed from is subordinate.[62]

On the other hand, Hooydonk points out that from a policy point of view, applying the specific status of seafarer to shore based crew might not be that beneficial. He emphasises that the status of the seafarer is based on the specific aspects that being employed at sea yields, which include 'a markedly international environment, physical fitness requirements, safety risks, discipline, long-term presence at the place of work and the commensurate absence from home with limitations on family and social life, and the possibility of a physical transfer to another ship'. None of these factors are present for shore-based crew, and it is not as easily defended to have their employment governed by the more specific rules of maritime law. [63]

[59] AAWA 2016 Position Paper p 47
[60] Carey, (2017), p 8-9
[61] MUNIN Research Project, Deliverable 7.2 p 28
[62] MSC 99/INF.8, Annex 1, p 3
[63] Hooydonk (2014), p 413

Furthermore, applying this convention to shore-based crew simply by analogy is a task that might be better left for IMO, and one that arguably should not be the task of flag states alone, in concern of leading to a very uncertain and not so predictable landscape for maritime law.

There seems to be no clear conclusion as to the applicability of the STCW just yet, and IMO has argued both ways, but seem to be deciding on non-applicability.[64] For the case that the convention finds application, or for the case that the IMO amends it to apply, it contains requirements that would most likely need amendment to allow for unmanned ships as it currently stands, but this will be further examined in the next part 3.3.

[64] See part 5 of this thesis for IMO's current conclusions.

3.3 The transfer of crew functions to shore

3.3.1 Introduction

After having established in the previous chapter that the framework as it is, is most likely applicable to unmanned ships, the next examination concerns how unmanned ships will fit into this framework. The aim of this chapter is to answer the overarching question; can the functions of the onboard bridge crew be transferred to shore?

This question, as pointed out by AAWA,[65] is closely related to the question of whether the flag State could issue a safe manning document that the ship is 'sufficiently and efficiently manned' as is required by SOLAS Regulation V/14, even if there is not a single crewmember on board the ship.

This thesis focuses certain positions of the bridge crew, as these are the ones it is natural to transfer to the SBO to begin with. Firstly, it is discussed to what extent the duties of the *master* of a ship, as required by LOSC, may be transferred to a shore-based operator (SBO). Thereafter the duties of the Officer of the Watch (OOW) and the lookout will be examined

This Part 3.3 will only examine if there are any impediments to transferring the crew to shore. At this point, there will still be humans in control, so for the remotely controlled ships, there are no questions raised regarding replacing the human judgement with that of machines - there are still humans in loop to interpret, determine and control the ship. The legal questions raised when the human is out of loop and the ship runs on AI or is pre-programmed leaving the human out of the decision-making process will be discussed in Part 3.4.

3.3.2 Safe Manning

As presented above, the examination of whether crew functions may be transferred to shore needs to be in line with the safe-manning provision in SOLAS Regulation V/14. SOLAS Regulation V/14 requires the contracting governments to ensure that 'from the point of view of safety of life at sea' that 'all ships be sufficiently and efficiently manned' and issue a safe manning document as 'evidence of the minimum safe manning considered necessary to comply (…)'. Ensuring safety at sea is also expressed in LOSC Article 94 (3) (b) together with 94 (3) and 94 (4) (b). This duty includes taking measures to ensure that ships flying its flag have a crew 'appropriate in qualification and numbers for the type, size, machinery and

[65] AAWA 2016 Position Paper, p 43-44

equipment of the ship'[66] and in the same way as SOLAS prescribes sufficient manning to be in place.
LOSC also requires its contracting parties when taking the measures called for in Article 94, to 'conform to the generally accepted international regulations, procedures and practices and to take any steps which may be necessary to secure their observance'[67]. This rule of referencing-technique that LOSC frequently make use of to ensure the Convention stays up to date, requires contracting parties to LOSC to abide also by SOLAS thus increasing the legal relevance of the safe-manning provision in SOLAS, as well as the other convention this thesis discusses.[68]

The legal question to be answered here is then; can the flag State issue a safe manning document to a crew numbering zero?

The wording of the provisions in SOLAS V/14 and LOSC 94, which goal is to ensure that the ship is manned adequately to preserve safety at sea, evidently suggests that it is the 'contracting government' or 'every State' that needs to be satisfied. This is the interpretation of Veal and Ringbom as well stating that the regulation's aim is to 'establish a means by which the relevant administration may satisfy itself as to the safety credentials of a ship's manning, rather than calling for any particular mode of operability'[69]. What is evident from the wording of the provision as well is that there is nothing requiring at least one crewmember. A safe manning level seems to be subjective.

This is supported by IMO Resolution A.1047(27)[70] which provides that both level of ship automation and shore-based support may serve to reduce the relevant ship's onboard crewing requirements. This indicates that adequate manning is a relative concept dependent on the particular capabilities of the ship and opens for a crew of zero to be adequate, provided the safety of life at sea is intact.

[66] LOSC 94 (4) (b)
[67] LOSC Article 94 (5)
[68] LOSC refers to both manning, prevention of collision and seaworthiness in Article 94 (3) and all these are then covered by the reference to GAIRS.
[69] Veal, Ringbom (2017), p 107 with reference to R Veal, M Tsimplis, *The integration of unmanned ships into the lex maritima* (Lloyd's Maritime and Commercial Law Quarterly, 2017) p 303
[70] IMO Resolution A. 1047(27) on Principles of Minimum Safe Manning (30 November 2011) http://www.imo.org/en/KnowledgeCentre/indexofimoresolutions/documents/a%20-%20assembly/1047(27).pdf

National law seems to have interpreted this in the same way. UK Law requires the ship owner to submit its safe manning numbers depending on the vessel and nature of the voyage,[71] thus seemingly allowing adjustments based on the necessary crew and with that; submitting a safe manning number of zero.

Maritime Law Associations, pursuant to IMO's questionnaire on MASS,[72] that was answered by 19 Maritime Law Associations, seems to be split on how they've interpreted and implemented Regulation V/14. On the question of whether the national law implementing SOLAS V/14 require at least a small number of on board personnel or if a relevant authority have discretion to allow unmanned operations if satisfied as to its safety, about half of the answering MLA's did not rule out that it would have discretion to allow unmanned operations, either based on a lack of an express numerical requirement of crew or through an exception-mechanism.
The other half MLA's answered that under current law, unmanned operations are not allowed.[73] CMI also points out that these answers are given with a high degree of uncertainty, and the majority of MLA's answered that it *may* be possible to allow to make exceptions to allow for unmanned operations.

Carey refers to the Hong Kong Fir Shipping Co v Kawasaki[74] where Sellers LJ states that 'if the crew had been efficient and competent, the ship may have been seaworthy notwithstanding the numerical deficiency.[75].This indicates that it is the crew's competence and not the number of crew that is the definitive point, suggesting that so long as the SBO is competent to ensure the safe navigation, in common law, the manning level could theoretically be zero.

However, it is important to keep in mind that the very point of both SOLAS and Article 94 (4) and other provisions requiring specific manning on the ship is the safety at sea, and this is the obvious benchmark. Expecting flag States, IMO or ship owners to tolerate a lower standard is implausible.

[71] Merchant Shipping (Standards of Training, Certification and Watchkeeping) Regulations 2015 (UK) 782 Regulation 46 as examined and referenced by Carey, (2017) p 7
[72] MSC 99/INF.8, p 6
[73] It is important to note that CMI in this particular question of the report seem to have miswritten the numbers, and it seems to be that 9 MLA's answered positively, and 10 MLA's answered negatively, while CMI writes, 8 vs. 11
[74] Hong Kong Fir Shipping Co v Kawasaki Kisen Kaisah (1962, 2, WLR 474) UK
[75] Carey (2017) p 4 with reference to Hong Kong Fir Shipping Co v Kawasaki Kisen Kaisah (1962, 2, WLR 474) UK p 481

Considering this, entailing a strict interpretation of the wording of the provision may be taken into account for the opposite result. As the provision requires manning adequacy, this speaks in favour of prohibiting unmanned operability, since an unmanned ship is not at all 'manned' by definition, as pointed out by Veal and Ringbom.[76]

On the other hand, it cannot be excluded that the operation of an unmanned ship might actually become safer, as more functions are transferred to shore and to computing systems.[77] The human factor does account for most parts of casualties at sea.[78] Considering that the purpose of the safe manning rules is safety of life at sea,[79] this is a point which cannot be overlooked.

In any case, as the AAWA 2016 Position Papers points out, should a national administration decide that the functions of a master could very well be performed elsewhere, 'it is difficult to find a provision that would be directly violated by that decision'[80]. A 'manned' ship is not necessarily the same as an 'attended' one,[81] and the provisions requiring manning may arguably not be considered violated by removing the 'manning', if the ship is remotely 'attended' to.

In order to fully determine whether the flag State may allow for a manning of zero and still leave the unmanned ship in compliance with the international framework, there are other provisions that need to be considered in the process. While the arguments presented above go in both directions, it seems to open for the flag State's authority to determine a safe manning level of zero as sufficient. However, the transfer of the master and the lookout from the ship are two requirements that necessitate closer examination before concluding that the safety at sea is intact. These will be further elaborated on below in order to determine whether a shore-based crew may fulfil all the required functions leaving it 'safe' to have a ship manning of zero.

[76] Veal, Ringbom (2017), p 107
[77] Levander (February 2017), p 28
[78] Blanke (2016), p 4
[79] SOLAS Regulation 14 cf. the words 'from the point of view of safety of life at sea (…)
[80] AAWA 2016 Position Paper, p 44
[81] AAWA 2016 Position Paper, p 44

3.3.3 'Master of the ship'

LOSC Article 94 (4) (b) requires the flag State to ensure that 'each ship is in the charge of a master and officers who possess appropriate qualifications'. The title of the master most often refers to the captain or the chief commanding officer of the ship in his place. In order to ensure that an unmanned ship is safely manned from the point of view of safety of life at sea, it is necessary to determine whether the function of the master may be transferred to the shore-based operator and still be in compliance with the safe manning provision.

The wordings of the provision give limited guidance. The provision itself prescribes only the flag State's responsibility in ensuring that the ship is in charge of a competent master. As there are no further requirements, this does not present as an impediment to having the 'master' stationed on shore, the ship is still *in charge* of a competent master, so long as the SBO is properly educated.

However, the goal of the provision is ensuring safety at sea, as prescribed by Article 94 (3); 'Every state shall take such measures for ships flying its flag as are necessary to ensure safety at sea (…)' with regard to amongst other the manning of the ship, this including 94 (4) and ensuring a master is in charge of the ship, and as prescribed by SOLAS V/14 as incorporated into LOSC. The legal question to be answered is whether from a legal perspective, safety at sea is still intact when the functions of the master are transferred to the SBO.

The safety at sea is the benchmark for the provision and taking on a too evolutionary approach in interpreting the provision must be done with caution. As unmanned ships were not considered at the time of drafting, allowing the SBO by analogy to function as the master might be too much of an expansive interpretation.

Seemingly, this is the case as only 6[82] of the 19 answering MLA's in CMI's questionnaire summarised in MSC 99/INF.8, answered that they do not exclude that the remote controller could constitute the master, meaning 13 do exclude an SBO acting as master.

This is supported by the fact that interpretations *per analogiam* tend to be frowned upon in international law.[83][84] While it may not be talk of a direct analogy-use of the provision, as the

[82] British, Canadian, French, Panamian, Singaporean and US MLA's
[83] Hooydonk (2014), p 410
[84] See also for instance R Kolb, (2016), chapter VII Interpretati

term ‘master’ does not have a clear definition in LOSC that requires onboard presence, caution should be exercised.

Furthermore, in CMI’s questionnaire[85] the Danish Maritime Law Association answered the question on whether shore-based crew could be considered crew under their national law in a negative manner. Their national law contains a definition of crew, as did nine of the other answering MLA’s, and of these ten, nine expressly requires on board presence, including the Danish national law.
However, the Danish and Finnish MLA did not exclude still that persons working on shore might be ‘seamen’, despite reference to on board presence. The Danish MLA stated that ‘if an unmanned ship is a ship per definition, a person employed on that ship may be considered a crew member, although de facto not being on board the ship’, supported by the Finnish MLA stating that the definition does not rule out a broader interpretation under which ‘the crew performs its tasks from elsewhere and that focus should be on the functions performed’.

This broad interpretation of onboard suggest that as long as the result of the performance takes place on board, where the function is actually performed from is subordinate. This indicates that it is possible to interpret the master as the SBO, while his performance is taking place on shore, the effect and consequences of his actions take place on board.

In the same direction goes Hooydonk, who points out that the position of the SBO is really quite similar to that of an officer navigating in poor visibility. Heavy reliance upon automated navigational systems, auto-steering devices, radar and cameras to safely navigate rough waters, and the officer might even be faced with defective radar.[86]

As eloquently put by C H Allen; ‘Given present trends, one might soon encounter two watercraft of nearly identical design and equipped with identical sensors and navigation collision avoidance equipment and programming. Both could be engaged in the same work and both might be equally manoeuvrable. The only difference would be that one still carries a person who monitors a craft that is fully autonomous, while the other is completely unmanned’[87].

[85] MSC 99/INF.8, Annex 1, p 3
[86] Hooydonk (2014), p 414
[87] C H Allen, *The Seabots are Coming Here: Should they be treated as “Vessels”?* (The Journal of Navigation, 2012, 65), pp 751-752

Moreover, when moving towards an electronic bridge, laid out in the same manner as the bridge of a ship, the differences between the jobs of a 'master' and that of a shore-based 'master' will be even smaller.

All these arguments suggest that while the SBO is currently on shore, the tasks he will be performing on shore, are the same and equal to those performed by the master and officers on board, particularly as many tasks are now automated or autonomous. Whether the master performs these tasks on or off the ship, might arguably be of secondary relevance, the safety at sea is still intact which is the goal of the provision.

While there are clear benefits, the downside is the possible loss of communications between the SBO and the ship, and this might pose a danger to the safety at sea that is not present with a master on board the ship, thus challenging the purpose of the provision and as such possible compliance. This is a highly complex technical issue, and this thesis does not attempt to be exhaustive in its representation of this. It is necessary to build closer relations between law and technology to understand and to fully be able to answer this question.

But, the aforementioned fallback strategies presented by the AAWA[88] minimise the risks that come with possible loss of communication. Furthermore, the possible employment of COLREG Rule 18 on 'Responsibilities between vessels', which gives navigational priority to 'vessels not under command' do so even further.[89] In any case, while the risks that come with possible loss of communications are noticeable; the risks that are present even with a master on board are evident too, and which is more dangerous requires more testing of unmanned ships before concluding.

A loss of communications with the shore will require even remotely controlled ships to be able to operate autonomously for some parts of the voyage. How this will fulfil the requirements of LOSC Article 94 (4) (b) will be discussed in the next chapter.

Hooydonk argues that 'the shore-based vessel controller will be unable to reach with the same intuitive feel for the situation (or at the very least a good deal less). Because the operator will be dependent on the satisfactory operation of all the sensors on board and the transmission systems, new kinds of dangers will arise'[90]. For some time forward, until the testing of

[88] AAWA suggest strategies that could include taking manual control, slow down and proceed to next waypoint or return to previous waypoint, maintaining DP-mode, or navigate back to a preset safe location. See Part 2
[89] How this would apply to the situation of loss of communication is discussed in Part 3.5.
[90] Hooydonk (2014), p 406

unmanned ships has developed further, it is difficult to fully conclude how remotely controlling a ship will feel like.

In summary, while caution needs to be exercised in interpreting Article 94 (4) (b) too far, the provision itself gives little guidance, but seemingly it is silent as to the existence of a manning-requirement. The goal of the provision is safety at sea, which is arguably always the priority in the regulation of unmanned shipping in order to have the standards accepted by the participants of the industry. Flag States and their national law seems unconvinced still to allow the SBO as master, their definitions still contain an 'onboard'-requirements. But LOSC does not require onboard attendance, and flag states do not need to either. The requirement upon flag States is ensuring safety at sea with a competent master in command. The provision does not necessarily call for on board presence, it calls for ensuring safety at sea. This purpose is arguably still intact. The SBO is still required to be equally competent, the technologies are already in use, and the bridge on manned ships to a large extent consists of automatic or autonomous systems and technologies even today. The function of the SBO will be the same as that of a master, but his equipment is better, his training in operating and knowing the limitations of the system is better, and risk of distraction is smaller. A conclusion on the safety of manned vs. unmanned ships when it comes to loss of communications is difficult still and requires closer cooperation between the law and technology. For the case that the unmanned ship is not released into international waters until the safety is assured for, concluding that transferring the functions of the master to the SBO will still be within the limits of Article 94 (4) (b) and SOLAS V/14 is arguably a legitimate conclusion.

There are still some functional problems to be solved when removing the SBO. This thesis previous Part 2 describes how a ship may function without anyone on board, using AAWA's position paper and their suggested ship. Two particular issues arise here. In mooring- and unmooring-situations an SBO is insufficient and when it comes to the extensive body of rules about the physical ship's documents to be kept on board. For the mooring-situations AAWA predicts that shore-based crew in each port will be necessary, not least to secure the cargo.[91] When it comes to the documents-issue this needs digitalisation, to ensure unmanned ships are still seaworthy.[92] This project is already on the steps. E-certificates are introduced slowly, and in April 2017 Singapore, Denmark and Norway signed an MoU to promote the adoption of E-

[91] Carey (2017) p 16
[92] It is a breach of the shipowner's seaworthiness-obligations to not carry on board the required documents. See discussion in Stephen Girvin, *Carriage of Goods by Sea* (Oxford University Press, 2011), p 388

Certs on vessels registered under their flags,[93] hopefully making way for this to become more common and relieve this problem.

Both the AAWA and the MUNIN study[94] project that the shore-based operators will function as the master, as they are the ones monitoring and navigating the ship[95], at least for the remotely controlled ships. The MUNIN study pronounces it as 'evident' that the remote operators take the roles of the master and chief engineer, and also of the company[96].

It seems that when it comes to the requirement of a competent master in charge of the ship, this could be fulfilled by an SBO. It requires some facilitation in berthing and mooring, and it requires e-certificates to ensure proper documentation is in place to ensure that the master's seaworthiness obligations are kept. When it comes to the ensuring the safety at sea, this is difficult to conclude upon and this is not attempted to do in full here either, but for the case that the safety can be assured, it seems that transferring the functions to an SBO is within the limits of Article 94 (4) (b).
A different question is whether this is desirable. In a short-term perspective it might be functional to interpret the framework in such a manner that it allows the SBO as a master, but in the long term there are factors here that suggest a new framework, amendments or guidelines are preferable, not least to ensure proper training and that the functions of master in berthing, mooring, and presenting documentation is maintained. This will be discussed further in Chapter 4.

[93] https://www.mpa.gov.sg/web/portal/home/media-centre/news-releases/mpa-news-releases/detail/c241463d-0caa-445b-93b7-0b84a5861326)
[94] MUNIN Research Project, Deliverable 7.2 p 19
[95] Carey (2017), p 16
[96] MUNIN Research Project, Deliverable 7.2 p 18

3.3.4 The lookout and OOW

In the pursuit of examining the legality of the transfer of duties from a ship's bridge to an SBO, the initial question was raised on whether a ship with a crew numbering zero on board could still be considered 'sufficiently and efficiently manned' pursuant to SOLAS Regulation V/14 as these questions are closely related. Up until now we have seen that the requirement for transferring the duties of the master of a ship to the SBO is mainly a question on whether the safety at sea is still intact, and this is answered in a positive manner. The next question to be raised here is whether the functions of the lookout and the Officer of the Watch (OOW) may be transferred to the SBO as well.

The OOW is a deck officer in charge of the watchkeeping and navigation, being a representative of the master. The OOW is in charge of the bridge team including the lookout, whose task is to maintain a continuous watch of the sea, usually from the bridge, and report any kind of obstacles or hazards. The lookout is not to have any other tasks but the lookout-duty and reports to the OOW his observations.

An important distinction must first be drawn. In this chapter 3.3.4 it is only examined whether the *function* of the lookout may be transferred. The replacement of human *judgement* in the lookout- and OOW-function is discussed in part 3.4. Different levels of autonomy raise different questions. The level discussed here regards the remotely controlled ship where the human is still in loop and exercising said judgement, while the level discussed in 3.4 regards full autonomy where the human is out of loop and the ship operates on AI or is pre-programmed.

Rule 5 prescribes that 'every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances (…) so as to make a full appraisal (…) of the risk of collision'. The interesting part when we are now discussing only the transfer of functions is the first part of the provision.

As evident from Rule 5, the lookout applies to 'Every vessel', and is as such neutral in respect of whether crew is on board or otherwise, thus requires unmanned vessels to abide. In applying to 'every vessel' it also places the responsibility of maintaining a lookout on the master of the ship, and how this lookout is best kept.

The STCW Code Chapter VIII entitled 'Standards regarding watchkeeping' demands that "the officer in charge of the navigational watch shall keep watch on the bridge" and may "in

no circumstances leave the bridge until properly relieved"[97]. Regulation VIII/2 (2) (1) states that 'officers in charge of the navigational watch are responsible for navigating the ship safety during their periods of duty, when they shall be physically present on the navigating bridge or in a directly associated location (…)'.[98] These are not the only provisions regarding watchkeeping in the STCW, but these are used as examples.
Both the watch-duty and the lookout-duty seem require the use of sight and hearing, as this is inherent functions in the watchkeeping-duty as well, and they are examined together here on account of their similarities and close relation.

The key question here is whether Rule 5 and STCW's watchkeeping provisions are broad enough to authorise a replacement of the human lookout with technology. This seems to raise three questions; (1) Does the function require people? (2) Does it require the people to be on board, and (3) for the purpose of Rule 5; Is the lookout still 'proper', which is a question of whether 'all available means appropriate' are in use, when performed from shore? These questions are, just like the above discussion, viewed in the perspective of the safe-manning provision in SOLAS V/14 to ensure the overarching purpose of safety at sea.

The first question (1) concerns whether the lookout and the watch duty require people. The relevant parts of the provision concerns maintaining a lookout 'by sight and hearing as well as by all available means appropriate in the prevailing circumstances' in Rule 5 and the 'keep watch' in STCW. It is difficult to interpret the wordings 'sight and hearing' as a task that could be performed without actual humans. Sight and hearing do require eyes and ears, and it seems clear that a human necessarily will still need to be in loop for this to happen. Both the COLREGs and the STCW in these two provisions evidently require human perception to be in place.

However, it is not a given that the lookout is required to be on board to fulfil this task. This raises the next question; (2) is it necessary to have the human perception and presence *on board* the ship?

Firstly, it seems clear that the sight and hearing part is a flexible formulation that does not preclude that sight and hearing could be performed by a human via the use of cameras and auditory aids, so long as the available technology ensure the controller will have an accurate overview of the situation in order to act in due time to the same extent or better than if he had

[97] STCW Chapter VIII Part 4
[98] STCW Regulation VIII/2 (2) (1)

been on board. The same could be said for the requirement of 'keeping watch' in STCW. AAWA in referring to the Llana&Wisneskey Handbook of the Nautical Rules of the Road points this out this stating that the use of vague terms such as *lookout* and *appropriate* 'provides flexibility for how such lookout is organised on board.[99]

Furthermore, as the AAWA also points out, the purpose of the look-out is to ensure that whoever controls the ship is aware of what is going on around, in order to make informed decisions and avoid collisions[100]. This is arguably also the function of the OOW, but he takes his information from the lookout, in addition to keeping watch himself. When this is the purpose, it seems there is no impediment to transfer to the SBO, as long as the technology allows the SBO to have the same perception.

AAWA argues also that the term look-out as used here 'does not necessarily denote a person, but rather the systematic collection of information'[101], indicating that this provision might not require actual human perception, at least not from on board. Farwell's Rules of the Nautical Road supports this, stating that the cases that have interpreted the lookout requirement over the years 'waver between an emphasis on the *function* of the lookout and the *person* performing it', and that the text of Rule 5 focuses on the function rather than the persons performing it.[102]

In conclusion, the requirement of sight and hearing seem to present no difficulties in transferring the functions to the SBO as long as he can perceive equally well via cameras and auditory aids. The question is then, with regards to COLREG Rule 5 what the legal content of the 'all available means appropriate'-requirement is. The STCW requirements of physical presence will be discussed afterwards.

While the term 'sight and hearing' may be possible to fulfil via an SBO through audio-visual methods, the COLREG Rule 5 also requires the lookout to be 'proper'. A proper lookout is one that uses 'all available means appropriate' *as well* as sight and hearing. The wording here indicate that sight and hearing is not enough. This requirement arguably applies to the OOW as well, he is the one responsible for the bridge-team and will be the one responsible for an improper lookout. The question that needs answer here is (3) the whether the requirement of a

[99] AAWA 2016 Position Paper p 46, referring to the C Llana & G. Wisneskey, *Handbook of the Nautical Rules of the Road* (3rd online edition, 2006, updates in 2011), available at http://navruleshandbook.com
[100] AAWA 2016 Position Paper, p 46
[101] AAWA 2016 Position Paper, p 46
[102] Farwell's Rules of the Nautical Road (Naval Institute Press, 8th Edition, 2005) with further references, p 131

proper lookout using 'all available means' requires people on board, despite the sight- and hearing part may be fulfilled remotely.

Requiring all available means is a question of ensuring that a 'full appraisal' in detecting risk of collision is ensured, the goal is to make sure to the fullest extent possible, that the collision is avoided.

This is an important point, as again, the overarching goal of COLREG is the safety in prevention of collisions. As with the above discussion on master, ensuring safety at sea is the overarching goal and the purpose of COLREG and STCW, as well as all regulations concerning unmanned shipping. Particularly when keeping in mind that these provisions purpose is to avoid collisions, and the nature of the collision regulations most often involve more than one ship. A deterioration of the current standard of safety and prevention of collision will not be tolerated by the industry. The discussion on whether a transfer of the lookout- and watchkeeping functions will still ensure the safety at sea is therefore necessary also here.

This is to a large extent a question of whether the technology is adequate. The reference to means 'in addition' to sight and hearing is, by Farwell's interpreted as a reference to 'radar and radio' or 'various scientific instruments'.[103] These means are already in use in addition to the sight and hearing via audio-visual technology read by the SBO, indicating that an unmanned ship would be in compliance.

It is projected by the MUNIN research project, that camera technology combined with computer vision in a visible and infrared area provides a safer perception of a situation than a human lookout.[104] This is a strong indication that a remotely controlled ship or an autonomous ship that is supervised are both within the text 'all available means appropriate'. AAWA also projects that an autonomous ship will have 'superior 'available means' than a manned ship', when it is equipped with multiple sensors and the information of the ship's surrounding is accurate.[105] Both these projects thus suggest that the technology to be utilised by the SBO in fulfilling the function of the lookout will be fulfilling the requirement of 'all available means appropriate'.

[103] See i.e. Farwell's Rules of the Nautical Road (Naval Institute Press, 8th Edition, 2005) with reference to 'The *Homer*, [1973] 1 Lloyd's Rep. 501 (C.A.) (U.K), p 133
[104] Blanke et al., (2016) p 4
[105] AAWA 2016 Position Paper, p 16

One of the previous concerns with the lookout and watchkeeping duty was that of fatigue and reduction of safety levels, and hence the 'all available means appropriate' was required. As AAWA points out, when the lookout and watchkeeping duty are performed remotely, the usual concerns related to fatigue and reduction of safety levels associated with reductions of onboard crew is mitigated, as they are compensated by the functions performed remotely[106]. This suggest that the 'all available means' will be taken care of, the purpose of the requirement is fulfilled namely avoiding poor lookout due to fatigue.

In summary, the issue of whether the 'all available means appropriate'-term is fulfilled is a complex technical issue and it cooperation between law and technology to fully establish that the technology is equally or superior to the current manual lookout and watchkeeping. But the abovementioned visioned technology as presented by two of the largest projects on unmanned ships, namely AAWA and MUNIN, indicates that the technology the future SBO will be utilising would be equally, if not safer, than the current one. The previous concerns with fatigue and distractions are dismissed, and the safety at sea will be assured for in an equal manner to the one currently accepted by the industry.
In conclusion, this would arguably fulfil the requirement of 'all available means *appropriate'*. Placing humans on board on top of this would be to go beyond the 'appropriate'-requirement and is not necessary. When the technology is as safe as the currently held standards, 'all available means appropriate' are in use. The conclusion seems to be that the duties of the lookout is transferable. For the OOW, this is the case too, but he also faces the requirement of physical presence on the bridge.

When it comes to the requirement of physical presence of the OOW on the bridge as the OOW may 'in no circumstances leave the bridge'[107] and must 'be physically present on the navigating bridge or in a directly associated location'[108], this provision on its head seems to bar the possibility of transferring the functions of the OOW to the SBO.
However, as previously mentioned, certain Maritime Law Associations has opened for interpreting a function that is performed elsewhere, but where the result and effect of the performance takes place on board as an onboard performance, leaving the place it is

[106] AAWA 2016 Position Paper, p 48
[107] The STCW Code Chapter VIII, 'Standards regarding watchkeeping'
[108] The STCW Code Chapter VIII, 'Standards regarding watchkeeping'

performed from subordinate.[109] The SBO will still be present on the electronic bridge, and the actions he performs will have its effect on board.
When it comes to the requirement of 'physical presence', another argument is that unmanned ships have no bridge, there will no bridge for him to be physically present at. This could be taken into account for the view that this specific provision is no longer applicable.

However, coming to this conclusion stretches the provision quite far. It is arguable that such an interpretation, if found legitimate, should be made at the international level, and not by the flag state. Particularly since this provision is aimed at prevention of collisions, and as the AAWA points out in connection with COLREG,[110] the nature of the collision regulations is that it always involves more than one ship, making it unjust to allow one flag state to interpret the framework in such an expansive manner, when the risk that comes with it hits all other ships as well.

The conclusion here is not clear, but as we have already seen, pursuant to IMO this provision might not be applicable at all, as STCW is currently considered not to have application to unmanned ships. In awaiting IMO conclusion on the applicability of the STCW Convention, this thesis discusses the possible transfer of the OOW, for the case that it finds application.

3.3.5 Conclusion

Initially the question raised was if the functions of the bridge crew could be transferred to the SBO. The thesis examined three functions that will most likely be transferred to an SBO, the function of the master, the watchkeeper and that of the look-out, all in a safe-manning perspective pursuant to SOLAS. A requirement for operation and compliance with the seaworthiness-obligation is that the ship is in possession of a safe manning document wherein the flag State attests that the ship is 'sufficiently and efficiently manned'. All three discussions conclude that the safety at sea is still intact but emphasises that this is to a large extent a question of whether the technology to be utilised is sophisticated enough. The current projects that have published reports indicate that this will not be an issue, and provided the technology allows the SBO to perform the functions in a manner as safe as on board, the safety at sea-requirement presents no impediments to the transfer of functions to shore, but

[109] See presentation of the research above, p 28 of this thesis. With reference to MSC 99/INF.8, Annex 1, p 3
[110] AAWA 2016 Position Paper, p 43-44

the requirement of physical presence of the OOW might, provided STCW is at all applicable to unmanned ships.

However, some of the interpretations of provisions and wordings will need to move away from the ordinary meaning given to the words and interpret them in an evolutionary manner. The goal of the LOSC, SOLAS, COLREG and STCW are all to ensure safety at sea, prevention of collisions and protection of the marine environment. In the perspective of uniformity where only the goal of these conventions are weighted, allowing unmanned operations is projected to lead to these goals being fulfilled to a larger extent than what is currently the situation, as well as more efficient and cost-beneficial shipping-climate. But, while the goals of the conventions are still satisfied after having interpreted the conventions in an expansive manner, it is questionable whether this is work that should be left to the flag States.

AAWA submits that any such clarification regarding COLREG should be made at an international level rather than by individual States.[111] This due to the fact that the nature of the collision regulations is that there is always more than one ship involved.[112] In acceding to COLREGs, STCW, SOLAS and LOSC the contracting parties presumed on board crew. Interpreting these provisions in such an expansive manner might go beyond what is reasonable. Allowing one flag state to interpret the framework expansively and evolutionary puts the risk of collision, safety at sea and pollution of the marine environment on all the other ships, that might have never agreed to this interpretation in acceding to any of these conventions. A coastal State's right to ban ships from its ports pursuant to LOSC Articles 25 (2), 211 (3) and 22 will alleviate this concern slightly, but the problem still arises in the remaining maritime zones.

This would go against VCLT and its favour of a more objective interpretation of the wordings.[113] The legal certainty and the predictability that is generally the goal of any convention is questioned. States, in acceding to these treaties seeks stability. Allowing self-interpretation in such an expansive manner goes against the goal that is a common agreement to preserve stability and predictability in the law of the sea.

[111] AAWA 2016 Position Paper, p 43-44
[112] AAWA 2016 Position Paper, p 43-44
[113] Robert Kolb, *The Law of Treaties: An Introduction* (Edward Elgar Publishing, 2016), Chapter VII Interpretati

While the provision in COLREG requiring a proper look-out contains vague wordings and lacks clear articulation, the requirement of a master, a physical presence of the OOW and a safe '*manning*', are not that vague. Arguably the look-out requirement might not need any amendment and is articulated in a manner that allows for expansive interpretation without jeopardizing the predictability or stability and opens for weighting the intention. Evolutionary interpretation of the look-out duty is also necessary, which over the years have seen more technological development than many other functions.

While it seems the framework isolated allows for the flag state to issue a safe manning document to a ship which has transferred all its bridge crew to shore, the desirability of putting this responsibility on a flag state is questionable. This thesis concludes that employing an evolutionary interpretation of the current regulatory framework is best left for the IMO, at least when it comes to the functions of the Master and the OOW. How this may be done is briefly discussed in Part 4.

3.4 Duties upon the crew when the ship is operated on artificial intelligence

Up until this point, this thesis has looked at the functions performed by the bridge team and whether the framework allows these to be transferred to the Shore-Based Operator of a remotely controlled ship. The next question to be answered is how the duties of the bridge team can be fulfilled when the ship is autonomous. This is a question of whether the human can be replaced in the decision-making process and transferring all decision-making to an algorithm.

The above presentation of the autonomous ship shows that when the ship is fully autonomous the human is out of loop. The autonomous ship will be pre-programmed or operate on artificial intelligence. The ship is self-guided and process data themselves and only informs the operator in case of an emergency. This raises the question as to what degree the legal framework allows for the human judgement to be replaced in the decision-making process. The same provisions as the ones examined above will be examined, namely the duties of the master and the lookout and OOW.

This chapter does not discuss the cases of 'autonomous' ships when are continuously monitored by an SBO. Depending on the situation surrounding the SBO, he would still be monitoring the cameras and sound-receptacles and keep the watch duty. For these cases the situation is similar to the one where it is remotely controlled, as discussed above, and the arguments and conclusions presented there would arguably apply directly to these ships as well.

3.4.1 Watchkeeping and lookout for fully autonomous ships

The above discussed provisions in COLREG Rule 5 and STCW Chapter VIII Part 4 both require that a human is utilising its sight and hearing to keep watch. COLREG Rule 5 prescribes that 'every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances (…) so as to make a full appraisal (…) of the risk of collision'. This could arguably be interpreted into the watchkeeping duty as well, human sight and hearing is no use unless the information is interpreted and used to avoid the risk of collision. Farwell's prescribes that also the OOW is the be interpreting the situation, in stating that part of the lookout-duty in Rule 5 is

communication of information to the OOW, so that he 'can make a full appraisal of the situation'[114].

It seems evident that autonomous ships utilising pre-programmed algorithms to operate could hardly meet the requirements of sight and hearing. An algorithm or a pre-programmed ship cannot perform the sight and hearing, not on board nor via audio-visual aids. For the time being this requirement may not be met by an autonomous ship. Maybe a different conclusion will be possible in the future if the algorithms are clever enough to mimic human interpretation and intuition at some point.

The above-mentioned provisions also require human judgement, in addition to human perception. As do the COLREG Rule 2 (a) stating that 'nothing in these Rules shall exonerate any vessel, or the owner, master or crew (…) from the consequences of any neglect to comply with [the] Rules or (…) any precaution which may be required by the ordinary practice of seamen or by the special circumstances of the case', or as many referred to as the requirement of 'good seamanship'. This provision presenting as an exception from COLREGs , should good seamanship make that necessary is evidence that COLREGs fundamentally require a human in loop. 'Good seamanship' is a reference to years of experience and impeccable intuition and common sense. The duty of a seafarer is inherently the job of a human, and

COLREG Rule 5 require 'appraisal', meaning an act of assessing something. Thus, referring to the human judgement. The watchkeeping duty in STCW arguably contains this element as well, cf. the above-mentioned explanation that sight and hearing is of no use unless the information is interpreted to avoid risk of collision.

Autonomous ships relying on camera sensors, radar and control algorithms could not replace the 'human input in surveying and assessing the situation and collision risk'[115] that these provisions require according to Veal and Ringbom. This illustrates an important point; whether human judgement may be replaced in the decision-making process does to a large extent depend on the available technology.

The AAWA Position Paper points out that from a technical point of view it is probably feasible to create algorithms that comply very diligently with the steering and sailing rules of

[114] Farwell's, p 135 with references to United States v. The *Collette Malloy*, 507 F-2d 1019, 1975 A.M.C. 938 (5th Cir. 1975); The *Canon Forest* v. The *Beishu Maru*, 1979 A.M.C. 1205 (D- Or- 1979)
[115] Veal, Ringbom (2017), p 110

COLREG. The problem is the combination of this with the good-seamanship requirement, as expressed in Rule 2. This rule gives precedence to good seamanship over its own provisions. What constitutes good seamanship is 'a matter of fact to be assessed after consideration of all relevant prevailing circumstances'[116], and AAWA points out that incorporating this 'good seamanship' into any automated navigation programme will present with serious difficulties.[117]

It seems that the relevant provisions as they now stand require a human to be in loop for the decision-making process. This is partly due to the fact that the technology currently available, pursuant to the AAWA, is not able to mimic the human intuition, common sense and seafarers' experience. And, if the technology ever reaches such a point, discussing whether it would fulfil the requirements would be a discussion that would require advanced technical insight and advanced knowledge of the law.

A temporary conclusion while awaiting further technological advance is therefore that technology may not replace the human in the decision-making process. Autonomous ships are seemingly not able to be in compliance with the current regulatory framework.

3.4.2 'Master' of a fully autonomous ship

It has already been discussed whether the requirement in LOSC Article 94 (4) (b) that requires the flag State to ensure that 'each ship is in the charge of a master and officers who possess appropriate qualifications' is possible to transfer to the SBO. This was answered in a positive manner. The question raised here is whether the master can be replaced in the decision-making process. The requirement of a 'master in charge' is arguably a reference to an actual person. Being 'in charge' comes with duties and responsibilities for the rest of the crew, functions that cannot be replaced by technology, the algorithm cannot 'take charge', at least not with the current available technology. The task of a master cannot be fulfilled by a pre-programmed ship, nor one operated on artificial intelligence, these cannot take charge. Interpreting the programmer as the master will render the programmer in charge of duties he has no capabilities to solve, not to mention the liability-questions this would raise.

The duties of the master cannot be replaced by technology.

[116] AAWA 2016 Position Paper, p 46-47
[117] AAWA 2016 Position Paper, p 47

3.4.3 Conclusion

The above examination show that human judgement is fundamental in the current framework. Human assessment, leadership and intuition cannot, for the time being be replaced by technology. And should that ever be possible, it is not a given that it would fulfil the provisions, nor be desirable then either. In conclusion, the human may not be replaced in the decision-making process when it comes to the bridge crew.

3.4.3.1 Suggested solutions to possible non-compliance with SOLAS and COLREGs for remote controller and autonomous ships

With regards to COLREGs, this thesis' above conclusion is that as it currently looks these regulations will most likely allow for the operation of remotely controlled vessel, as the human is still in loop. The autonomous vessels will not be in compliance, as COLREG fundamentally requires human input as expressed in amongst other COLREG Rule 2 on good seamanship.

Solving this non-compliance issue has been countered with suggestions on smaller amendments to Rule 5 on lookout. It has been suggested to add 'manned' to the 'Every vessel shall at all times maintain a proper lookout'-requirement[118][119], to have it sound as 'every *manned* vessel shall at all times maintain a proper lookout'. Other suggestions include adding to Rule 3 (g) a new letter stating: 'self-propelled vessel while unmanned and operating autonomously',[120][121] which deems the ship 'restricted in her ability to move' giving her navigational priority.

This is not possible for autonomous ships. The above-mentioned fundamental principle of COLREG that ships are controlled by human beings, as expressed in Rule 2 is an impediment to autonomous ship operation regardless, and it will require a new framework to be adopted. For remotely controlled ships this might be an option, but as emphasised also in the next part 3.5, the goal is not to have unmanned ships exempted from the framework, but to have the law work together with unmanned ships to ensure continuous safety at sea.

With regards to SOLAS, there are three different categories of exemptions here that could exempt certain ships from parts of SOLAS. The first (1) category are those listed in Regulation 3, but none of these are relevant for this thesis. The second (2) option is Regulation 4 (b) which allows the flag state to exempt 'any ship which embodies features of a

[118] C H Allen, (2012), p 751
[119] Carey (2017), p 15
[120] C H Allen, (2012), p 751
[121] Carey (2017), p 15

novel kind' from the requirements of chapters II-1, II-2, III and IV if their application might 'seriously impede research into the development of such features (…)'. This thesis has only focused on Chapter V and this does not apply to that chapter. The third (3) option is Regulation 5 where the flag state may accept an equivalent solution if it is satisfied that it is at least as effective as that required by the present regulations. This exemption however only applies where SOLAS requires that 'a particular fitting, material, appliance or apparatus or type thereof' be fitted or carried in a ship. This amounts to zero as well, when this thesis focus on bridge crew, and this can hardly be subsumed under 'fitting, material, appliance or apparatus, or type thereof'.

3.5 The link between the remotely controlled and the fully autonomous

This thesis has discussed the legality of unmanned ships when the bridge crew is moved and when it is removed. However, this discussion raised the question of what would happen if a remotely controlled ship lost the connection between the ship and the shore-based operator. This part takes a closer look at this.

Firstly, a look at COLREG Rule 18 on 'Responsibilities between vessels' which gives navigational priority to, amongst other, 'vessels not under command'. Rule 3 (f) defines the term 'vessel not under command' as a 'vessel which through some exceptional circumstance is unable to manoeuvre as required by these Rules and is therefore unable to keep out of the way of another vessel'.

One could argue that an unmanned vessel that has lost its connection to shore is a vessel 'not under command', as suggested by Veal and Ringbom.[122] It has through an exceptional circumstance, such as its SBO no longer being able to control it, found itself unable to manoeuvre. This would improve the safety at sea-concerns related to this situation, provided technology finds a way for the vessel to demonstrate that it is not under command to other vessels.

Regardless of Rule 18, The AAWA has suggested certain fall-back strategies for the purpose of loss of connection. These are presented earlier, but repeated here: taking manual control, slow down and proceed to next waypoint, or return to previous waypoint, maintaining DP mode[123], or navigate back to a pre-set safe location.[124] But carrying out any of these suggestions without connection to the shore control centre would require the ship to operate autonomously. As we have previously seen, an autonomous ship is in compliance with neither COLREG, STCW nor LOSC.

All the while the technology cannot guarantee a continuous connection to shore, the remotely controlled ship will need some degree of autonomy for these possible parts of the voyage where the human is out of loop. The logic conclusion here is therefore that for as long as the framework requires human judgement in the decision-making process, not even the remotely

[122] R Veal, H Ringbom (2017), p 111
[123] DP mode or Dynamic Positioning is a system that maintain the ships position by pinpointing wind and wave data which would otherwise make the ship loose its position, without the use of anchors
[124] Fallback strategies as suggested by AAWA 2016 Position Paper, p 8

controlled ships will be in compliance with the framework, all the while there is risk of connection-loss.

Another question is whether the fact that a ship is unmanned and crewless on its head could place the ship under navigational priority through COLREG Rule 18. While it could be interesting to discuss whether unmanned operability could be covered by Rule 18, it is not a desirable outcome. The goal is not to exempt unmanned ships from parts of the regulatory framework, but to ensure the continuous safety at sea, prevention of collisions and protection of the marine environment also after the introduction of unmanned vessels to the oceans. As previously mentioned, the safety at sea is the ultimate benchmark. The participants in the industry would never accept a lower standard than the current one. However, Goggarty and Hagger makes a valid point when they submit that as an SBO might be monitoring several ships simultaneously and this makes it questionable if she is in fact 'under command'[125], however the provision is not aimed at this.

Carey's examination shows that courts have interpreted the words 'not under command' as an exceptional circumstance caused by failure or damage, and not as a normal mode of operation, such as the mode of an unmanned ship[126] [127].
This interpretation is supported by Veal and Ringbom stating that the term ''exceptional circumstances' clearly refers to circumstances other than a vessel's ordinary operational arrangements'.[128]

A last option is the part of COLREG Rule 18 which gives navigational priority to a vessel which through the nature of her work is 'restricted in her ability to manoeuvre'. While this would be the case for the remotely controlled ship if the SBO is no longer able to control her, this provision is aimed at vessels that is restricted through the *nature* of her work and does not apply to the normal operational mode of an unmanned ship.

[125] Carey (2017), p 13 with reference to Brendan Goggarty and Meredith Hagger, *The Laws of Man over Vehicles Unmanned: The Legal Response to Robotic Revolution on Sea, Land and Air* (Journal of Law, Information and Science, 73, 2008) p 115.
[126] Carey (2017), p 13
[127] *Mendip Range V Radcliffe* [1921] 1 AV 556, p 571, as referenced by Carey (2017) p 13
[128] Veal, Ringbom (2017), p 111

4 MSC 100 and the IMO Conclusions on MASS

At the Maritime Safety Committee (MSC)'s 99th session, the MSC requested the Secretariat to submit a consolidated report on the work performed by Member States and organisations in considering regulatory arrangements for the use of MASS based on the documents presented to the Committee. This report was made August 9th 2018 and has reviewed large parts of the legal framework provision by provision, amongst them the three IMO-conventions that this thesis examines. Only paragraphs or extracts from the specific provisions were considered, and the report emphasises that it is not intended to replace the source document. The relevant results for this thesis are presented here.

4.1 STCW

The summary shows that the MSC 99/INF.3 concluded that unmanned ships could comply with STCW, provided it is technically possible and the equivalent level of safety is preserved. This would also render the bridge 'manned' under the STCW Code, and in accordance with current regulation. However, in the newer MSC 99/INF.14 the conclusion is non-applicability as the Convention applies only to seafarers serving on board seagoing ships and suggests new regulations.

4.2 COLREGs

MSC 99/INF.3 submits that the core element of COLREG is that ships are controlled by humans through seamanlike assessment. It is decisive 'who' is controlling the ship, not from 'where'. Remotely controlled ships will fulfil the requirements of COLREG to the extent that the technology provides sufficient situational awareness. Fully autonomous ships do not meet the requirements, as long as algorithms do not reflect human intuition. MSC dismisses the possibility of considering unmanned ships as not under command as a normal mode of operation. For the fully autonomous ships it suggests new international regulations, rather than develop algorithms that can fulfil COLREGs. Newer reports only further develop these suggestions, and this seems to still be the ruling view of the MSC.

4.3 SOLAS

MSC 99/INF.3 establishes that it is the safety of life at sea that is the goal, and that ships may operate with no crew at all and still be within the wordings of Regulation V/14 on safe manning. It emphasises that this is subject to the flag State's discretion, and that flag State's approaches and their view on safe manning, today, differs much. This may in itself present a

regulatory barrier. They conclude that neither LOSC 94 (4) (b) nor SOLAS Reg V/14 will present barriers to remotely controlled ships, but for autonomous ships it must validated that an autonomous ship is capable of operating without being manned according to the ship's type, size, machinery, equipment and voyage plan. The following MSC reports however states that it is unclear whether the relevant maritime administration has discretion to permit unmanned operations. Interpretation of the master needs to be clarified first. It seems to conclude that fully autonomous ships cannot comply with Reg V/14.

5 Solutions to non-compliance

5.1 Introduction

We have seen that when it comes to the remotely controlled ships, the framework does not pose the greatest legal challenges, but that it is questionable how much power it is desirable to place on the flag state in interpreting the framework expansively and evolutionary.
The position is different for the autonomous ships, where the framework efficiently bars the operation when it requires human judgement in the decision-making process.

The most expedient way of making use of this new technology would be to have unmanned ships fall within the frame of the current regulatory framework, and a goal would be to have interpreted the rules so as to allow for the operation of at least the remotely controlled ships under the current conventions, as these will be the first to come into operation.

The IMO's Maritime Safety Committee and their working group on MASS is reviewing the legal framework on a provision by provision basis. The current status of their work is described above under Part 4. This is a time consuming and labour-intensive activity that is projected to take years. Some suggest that the technology is already too far ahead of the framework and that a new framework will be necessary anyway, and preferably sooner. These arguments are reviewed here.

5.2 The way forward

A question to be raised is whether IMO's current strategy in walking through the legal framework provision by provision is the most efficient method of clearing way for unmanned ships. The Danish Maritime Authority raises questions suggesting that maybe the time- and labour-consuming provision by provision walkthrough is not necessary?[129] The IMO has already concluded that new provisions are required for several of the conventions they examine. It could be argued that it is better to get to work with developing new guidelines and soft law aimed specifically at unmanned ships, instead of applying the current framework that is so clearly adapted with manned ships in mind.
Furthermore, developing new guidelines and conventions are a time-consuming activity. The newest addition to the IMO-Conventions, the Polar Code, took 15 years from guidelines were

[129] International Workshop on Maritime Autonomous Surface Ships and IMO Regulations, DMA, as published by National Maritime Research Institute, http://www.nmri.go.jp/study/contribution/WS_on_MASS/(6)%20Analysis%20of%20Regulatory%20Barriers%20to%20Autonomus%20Ships.pdf

adopted to the amendments to IMO-conventions went into force[130], and almost 30 years since the focus of the distinct challenges in polar waters emerged after the Exxon Valdez incident in 1989. If a new convention is the goal, reaching the preferred number of acceding States also takes quite a few years, and this is necessary to affect real change at the international level.

The current framework, as examined in this thesis, do not pose the greatest of challenges for remotely controlled ships, and these are the first that will enter into operation. There might be room in the conventions to interpret the framework to allow for remote operation, but it is necessary with a common understanding of how far it is possible to go.
Prioritising to develop guidelines and allow a flag state to interpret the framework to suit remotely controlled ships, even if only for small-scale testing, would allow the technology to develop further, and the safety of these ships to be more established. This would lead to a more stable and uniform interpretation-practice as well. And for the remotely controlled ships, guidelines may even suffice for allowing operation. Starting this process early will lead to the framework developing in a more uniform manner in a longer perspective, and mandatory rules to be accepted earlier.

However, it is reasonable to ask if efficiency really is the goal. Unmanned ships ready for large-scale operation in international waters is a few years ahead, and it might not be necessary to stress with having the framework ready. IMO might take the next 2-4 years finish their regulatory scoping exercise on each of the conventions, but the technology that needs to be in place to determine safety at sea is not in place nor tested to secure safety at sea. When it comes to autonomous ships, the technology is not even invented. This is an illustrative example that it might not even be possible to determine whether an autonomous ship could comply with, i.e. COLREG Rule 2 on 'good seamanship'. It requires an algorithm to mimic the experience of a skilled seafarer, his intuition and common sense, that this provision requires, and the technology is not there yet.

This is a point that thesis has already emphasised; interpreting the framework is to a large extent a question of whether the available technology could ensure safety at sea to the same extent or better than the current manned ships are doing. Determining whether the safety of life at sea is intact, which is the requirement of SOLAS V/4, and also the goal of all these conventions is not possible at the moment, the technology has not yet been developed or tested.

[130] MSC/Circ. 1056, MEPC/Circ. 399, Guidelines for Operating in Arctic Ice-Covered Areas

It also needs to be pointed out that the desirability and functionality of unmanned ships in the shipping industry is not yet established. While the IMO and the academic society interprets the legal framework, it is the job of the industry to determine the feasibility and functionality. It is not a foregone conclusion that unmanned merchant vessels in cargo carrying capacity is the goal, and all that is left is provide a regulatory framework that allows for it.

DTU submits that 'it has been expressed that total autonomy is not necessarily the most appropriate or best economic solution for all types of surface vessels'[131]. Without going into the desirability of fully unmanned ships, this thesis notes that moving towards total autonomy is not necessarily the goal. That should be kept in mind when deciding on means to address unmanned ships in the legal framework. Arguably, this should also be in place before the IMO can reach a conclusion on whether to open the framework for operation of unmanned ships and if so, how to do it.

Testing of technology can be done within the limits of the territorial sea, such as the autonomous containership Yara Birkeland of Kongsberg Gruppen will be doing shortly. This could make it possible to lay out the possible technology and its limitations that is necessary to reach a conclusion on whether it fulfils the requirements of the regulatory framework.

In summary, a provision by provision walkthrough of the framework is not necessarily a drawback. Both solutions are propitious, one not necessarily more than the other. Awaiting further testing of unmanned ships, and following the development of new and improved technology, leaves it difficult to get very far with developing a new framework for a type of shipping that is not yet clear how will function. While IMO is currently assessing applicability and possible non-compliance and need for amendment or clarification, stakeholders in the industry has begun looking at the regulatory challenges. Amongst other, Lloyd's Register has published an 'Unmanned Marine Systems Code'[132]. Such classification societies and other similar organisations could be an interim solution while awaiting conclusions from the IMO.

[131] Blanke, et al (2016), p 5
[132] 'Unmanned Marine Systems Code' (2017)

5.3 A new treaty?

When IMO's regulatory scoping exercise on MASS comes to a conclusion and the technology is sufficient enough for new rules to be established, it is a question of how this to be done. Carey in noting that the COLREGs can and have been readily updated by the IMO, suggests a new annex to COLREGs, rather than bending the rules to suit autonomous ships.[133] This seems like the most viable solution, as the IMO at least in the aforementioned latest report, seems to conclude that autonomous ships could never fit into COLREG.

When it comes to the STCW the IMO is of the current opinion that this do not apply at all. As there is unanimous agreement that a new training and certificates regime is necessary for unmanned ships, a new convention will be necessary. The current solution with making a separate convention in the same style, as is done with STCW-F for fishing vessels is a feasible solution for unmanned ships as well. Another option is to amend STCW and remove the 'on board'- requirement and have STCW apply to unmanned ships as well. But as previously pointed out by Hooydonk, this might not be that beneficial. The status of the seafarer is based the specific terms that employment at sea comes with, and this is no longer the case for the crew of an unmanned ship.[134]

When it comes to LOSC 11 MLAs stated in CMI's questionnaire in MSC 99 upon questioning that inconsistencies with UNCLOS Article 94 (3) and (4) which include a number of obligations with respect to manning, may be resolved through measures at IMO level. The French and Irish MLA are of the opinion that UNCLOS would require amendment to allow unmanned ships. The remaining MLAs did not take a position, but some concluded that IMO measures would suffice to emphasise the aim of Article 94, which is to ensure safety of navigation. Three of these emphasised that as UNCLOS is a framework Convention, it seems just that the further details are worked out by IMO.

While the Brazilian, Canadian and Italian MLAs did not take a position on whether IMO could resolve potential inconsistencies in UNCLOS Article 94 (3) and (4) via (5), they considered the wording of the provision to exclude unmanned operations, but they were reluctant to exclude that a teleological interpretation could render the result different.

[133] Carey (2017), p 15
[134] Hooydonk (2014), p 413

Veal and Ringbom suggests soft law guidance would be the most appropriate and expedient options, at least when it comes to remote controlled operations. Considering that remote controlled operations are the first in line and adding that to the fact that prescribing new mandatory rules is a long way ahead, guidelines is an important first step. In addition, it opens for remote controlled ships to begin operation, while the viability of unmanned ships as a business area presents itself for the actors involved.

6 Concluding remarks

This thesis research question was to answer to what degree shipowners of unmanned ships can comply with the current regulatory framework, and as part of this determine applicability. With a focus on bridge-crew two larger questions have been attempted answered: (1) To what degree could certain bridge functions be transferred to shore, and (2) to what extent could the current technology replace the bridge crew in the decision-making process.

In focusing on the possible transfer of functions from bridge to shore, and the legality of replacing bridge team functions with technology in the decision-making process this thesis has discovered that this is a question of complex technical nature as well as law. Some questions were not possible to answer definitely, either because the technology does not yet exist or because it requires more thorough knowledge of the available technology then the author possesses. This goes to show that the transition to an era of autonomous shipping requires law and technology to work together on a plethora of areas to make sure that safety at sea is assured and reassured for.

The thesis concluded that the framework that currently applies to *ships*, will also apply to unmanned ships as these were found to be ships as well, with the exception of the STCW-Convention due to their on board-requirement. On this matter both this thesis, academia as well as IMO is undecided, but IMOs latest conclusion tends towards non-applicability, and there is no reason this should not be their final conclusion. This would render this thesis examination of the duties of the OOW, as prescribed by STCW superfluous. However, some of the remarks made illustrate that the function of the OOW as it is now will leave the ship in capacity to ensure safety at sea and will not require the largest of changes.

In determining the possible transfer of duties from the master and the lookout the thesis found that also here safety at sea was the most important factor and overarching goal to be met. The wide text of COLREG that is open for interpretation allows the function of the lookout to be transferred to the SBO. As for the ‘master’ of the ship a more expansive approach to interpretation had to be taken, but it showed that the provision does not require the master to be on board, only in charge, and that transfer is possible, but the requirement is sufficient technology to ensure safety at sea. However, IMO has yet to conclude on this area, and it will be interesting to see what the agree on.

As for the fully autonomous ships, these cannot be in compliance with the regulatory framework the way it currently looks. Today's legal landscape requires a human to take part in the decision-making process. This might change at a point in time when technology has come up with an algorithm that can mimic human intuition, seafaring experience and common sense, but even when that happens, it is not a given that this autonomous operation is desirable.

This bring a final point. While IMO moves on with its walkthrough of the provisions of the legal framework, the industry has the job of developing the technology to make it safe to transfer the functions of the crew to shore. Among the more pressing issues is making sure that the connection between a remotely controlled ship and the shore is reliable. Pursuant to this thesis part 3.5, the need for the remotely controlled ships to operate autonomously for parts of the voyage for the case that connection is lost, is effectively barring legal operability.

Continuous developing the technology is crucial considering that relying solely on technology to run a ship and replacing humans in the decision-making on board a ship is a much greater risk when on the area of unmanned shipping, than when moving towards unmanned cars or unmanned drones. For the case of an unmanned ship colliding, the impact on the marine environment, fragile as it is, will be catastrophically and possibly much worse than the collision of a car or a drone. Introducing unmanned ships must be done with the utmost of caution and will require extensive testing before introducing it into international waters. In the meantime, as this thesis projects that there is room for interpretation of the provisions, classification societies will do the job of developing guidelines in ensuring a uniform practice in the interpretation of the framework and a common understanding of how this should be done.

Maritime law has a long history of catering to the needs of the industry and is well armed for this task yet again. It survived the introduction of steam boats and steel production in the 19th century, two world wars and countless attempts at making bilateral and multilateral treaties, some even successful. The coming era of unmanned ships will unlikely be the death of maritime law but will once again prove 'the continuity and necessity of this branch of law'.[135]

[135] Hooydonk, (2014), p 423

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