



**MASTER OF SCIENCE IN MARITIME SCIENCE
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**The legal challenges of unmanned
vessels**

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Preface

This master dissertation marks the end of a fascinating year being submerged in the maritime world. It was a year filled with impressive port calls, exciting company visits and captivating lectures. During one of the company visits in London we were told about the trend of digitalisation and automation in the maritime industry. Due to my legal background, one of the first questions that came to mind was: “what about the legal consequences?”. After several months and visits to the library, I can present a (limited) answer to that question.

Researching the legal challenges of unmanned vessels was an interesting journey, because of the comprehensive maritime regulations and the thrilling digitalizing evolution. I would like to thank my supervisor Frank Maes and assessor Kristiaan Bernauw for guiding me during this experience. Their recommendations and triggers have kept me on the right course.

I also would like to thank my parents for giving me the opportunity of following the maritime science programme and supporting me through it. At last I would like to thank my loving girlfriend and pleasant classmates for making this year very entertaining. They were the wind to my sails.

21st May 2017

Pol Deketelaere

List of abbreviations

| | |
|---------|---|
| AAWA | Advanced Autonomous Waterborne Applications Initiative |
| AIS | Automatic Identification Systems |
| CLC | International Convention on Civil Liability for Oil Pollution |
| CMI | Comité Maritime International |
| COLREGs | Convention on the International Regulations for Preventing Collisions at Sea |
| DWT | Deadweight tonnage |
| EASA | European Aviation Safety Agency |
| EC | European Commission |
| EEZ | Exclusive Economic zone |
| ICAO | International Civil Aviation Organization |
| ILO | International Labour Organization |
| IMO | International Maritime Organization |
| ISM | International Management Code for the Safe Operation of Ships and for Pollution Prevention |
| ITLOS | International Tribunal for the Law of the Sea |
| LLMC | Convention on Limitation of Liability for Maritime Claims |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MLC | Maritime Labour convention |
| MUNIN | Maritime Unmanned Navigation through Intelligence in Networks |
| RAVEN | Remote-controlled and Autonomous Vessels for European and National waters |
| RPA | Remotely piloted aircraft |
| SCC | Shore Control Centre |
| SMS | Safety Management Systems |
| SOLAS | International Convention for the Safety of Life at Sea. |
| STCW | International Convention on Standards of Training, Certification and Watchkeeping for Seafarers |
| UAV | Unmanned aerial vehicle |
| UNCLOS | United Nations Convention on the Law of the Sea |
| UNCTAD | UN Conference on Trade and Development |
| VTs | Vessel traffic services |

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Part 1 Introduction

When you would ask people in 1970 how the world would look like in 2020, they would talk to you about robots, monorails, self-driving cars, and even flying cars. Aside from the latter, all other technologies are ready to come into our daily life within 3 years from now. Mobility is about to face a huge evolution driven by digitalization and automation. The road transport industry is preparing itself for self-driving passenger vehicles and ‘platooning’ or autonomous trucks. The same transformation is about to happen in the shipping business. Advanced software systems and IT technologies will increase the available data and will enable ships to navigate remote-controlled or autonomous.

Currently, several projects are researching and testing unmanned shipping. Most of these studies are expecting that the first remote-controlled or autonomous ships will come at sea by 2020. Yet the legal framework for unmanned shipping is still unprepared for this evolution. A large part of maritime laws and regulations are still dating back from the 19th century. Therefore, this dissertation will analyse how unmanned ships can fit into the maritime legal framework and what modifications are required to embrace unmanned shipping.

Different international conventions related to maritime law will be discussed. This dissertation will give an overview of whether unmanned ships will be subject to these conventions, whether these conventions will form challenges for unmanned ships and how unmanned ships can comply with the rules of these conventions.

First, I will look at the current state of affairs regarding autonomous transport, in the different transport modes. Secondly, the general benefits and challenges of unmanned shipping will be reviewed. Thirdly, the core of this paper will examine the legal challenges of unmanned shipping. In particular, this part will check whether an unmanned ship still is a ship, how it can comply with the duties from the law of the sea, what about the crewing and operational regulations, and who can be held liable for unmanned ships.

1.1 Definition

In order to talk about unmanned vessels, it should be clear what can be defined as an unmanned vessel. An unmanned vessel can be described as a vessel that is able to navigate from point A to point B, without requiring the support from a crew aboard the ship. For the purpose of this paper, only unmanned merchant vessels will be handled. The military use of unmanned crafts will not be discussed.

Unmanned vessels can however be categorized according to the level of automation.

The first type are the remotely operated vessels. The remotely operated vessels are being controlled and operated by human operator(s), located ashore in the Shore Control Centre (SCC). The ship is wirelessly connected with the SCC. The SCC is the place where the personnel receives all information and data through radars, sensors, satellites and other systems on the ship.¹ The shore-based operators will interpret all the data, transmit their commands back to the vessel and guide the vessel to its destination. These commands will then be carried out by the electronic system of the vessel.²

The second type of unmanned vessels are the completely autonomous vessels. With the autonomous vessels, a human operator is only required to put in the destinations and the vessel itself will navigate to these destinations without requiring further human interactions. These types of vessels rely on preprogrammed instructions and artificial intelligence to navigate autonomously.

The vessel collects different kinds of data from various sensors on board and continuously sends them to the on-board computer, which is able to process the data and sends commands to the engines, rudders, and other navigational and cargo care equipment. The autonomous vessel may be linked to a monitoring or command centre ashore, for intervening in maintenance or emergency situations.³

¹ F. SAFARI and B. SAGE, *Legal and Liability Analysis for Remote-controlled Vessels*, MUNIN, 2013, 18-19.

² P.W. PRITCHETT, "Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology", *Tulane Maritime Law Journal* 2015, (197) 199.

³ Ibid.

Throughout this paper, the term unmanned vessel will be used, referring to the overall category of both remote-controlled and autonomous vessels, where the distinction between remote-controlled and autonomous vessels is not relevant. In cases where the distinction is relevant, the specific term of remote-controlled vessel or autonomous vessel will be used.

Part 2 Distant future or futuristic?

2.1 Autonomous transport vehicles

This part will give an overview of how the other modes of transport are evolving in to autonomous transport. Especially autonomous road vehicles and unmanned aerial vehicles will be discussed.

Autonomous railway vehicles will not be handled in this paper, because these vehicles probably will only be able to operate in a protected or isolated infrastructure (as underground railways or monorails), to reduce the risk of collision with people or other vehicles. Due to the low friction of steel wheels on railways, the stopping distance with trains is much higher than cars. So, sensor systems must be able to detect items from very far ahead, while a person or vehicle can come on the railway in no time. This makes that human operation of ground railway vehicles is still - for now - the most interesting and safe way of operation.⁴

2.1.1 Autonomous road vehicles

Road vehicles that are able to drive autonomously are no longer a futuristic concept, they have already become reality. Currently it is one of the most researched technologies by private companies to get autonomous cars. The technology to let a car drive without any human interaction did not come at once; several steps of automation have been taken over the years.

- Level 0: Conventional vehicles: The car and all its functions are fully controlled by the human driver at all times.
- Level 1: Partial control systems: One function of the car is automated. The driver still is in complete control of the vehicle and is responsible for the safe operation, but the driver can opt to let certain systems control functions of the car, such as the acceleration or cruise control. The automated system can assist the driver in normal driving or emergency situations.

⁴ D. LAVRINC, *It's Not a Lack of Technology That's Keeping Trains From Going Driverless*, <https://www.wired.com/2013/04/why-arent-trains-autonomous/> (consulted 10 May 2017); P. SHEPPARD, *Autonomous vehicles: a railway perspective*, <http://www.theiet.org/sectors/transport/topics/autonomous-vehicles/articles/av-railway.cfm> (consulted 10 May 2017).

- Level 2: Short term driving systems: More than one function of the car is automated (e.g. acceleration and steering), but the driver must remain attentive when driving the car. The driver is expected to be available to take control at all times and still is responsible for the safe operation and checking the road. Within level 2, two functions can be automated at the same time, for instance cruise control and lane keeping assistance.
- Level 3: Limited self-driving automation: The driving functions are sufficiently automated to a point where the driver can safely engage in other activities, under certain conditions. This level of automation enables the driver to transfer full control of all functions to the automated system in certain traffic and weather conditions, like the autopilot function. A change in these conditions may require that a human driver takes back control. The driver needs to be available for occasional control.
- Level 4: Full self-driving automation: The car can drive fully autonomous. The driver is not required to be available for control during the car trip. A human driver is not even required to be in the driving car. The vehicle is able to carry out all driving functions and monitor the conditions on the road. The only thing the driver needs to do is putting in the destination. At this level, the vehicle can drive fully autonomous, without the intervention of a human driver.⁵

Currently the road-legal cars have already reached level 3. These semi-autonomous vehicles are being produced by the main car manufacturers. Electric car manufacturer Tesla was one of the first to offer functions such as self-parking, advanced cruise control, emergency brakes and semi-hands off driving in highway conditions. Most car manufactures have followed Tesla's lead, and have equipped their cars with these functions. These semi-autonomous features have already become a normal part of the road vehicles.

The next step to come is the fully autonomous vehicle. Several technology companies (e.g. Alphabet, Apple, Intel, ...), car companies (e.g. Tesla, BMW, Toyota, etc.) and start-ups are investing in the research and development of software and hardware in order to manufacture reliable fully autonomous cars. The majority of car manufacturers estimate that the fully

⁵ J. M. ANDERSON, N. KALRA, K. D. STANLEY, P. SORENSEN, C. SAMARAS, O. A. OLUWATOLA, *Autonomous Vehicle Technology: A guide for policymakers*, RAND Corporation, Santa Monica, 2016, 2-3.

autonomous cars will come on the market around 2020-2025. And of course, these car manufacturers are competing to be the first to introduce their driverless car.⁶

Google has already published several promising results of the testing of their autonomous vehicles. 'Waymo' ("Way forward in Mobility") is the self-driving car company of Alphabet⁷. In 2016 only, the fully autonomous car fleet of 'Waymo' had already covered a distance of approx. 1.022.000 km on the public roads of California and the test drivers needed to intervene only 124 times, or once in approx. 8.000 km.⁸

Tesla has already unlocked the Autopilot feature in the existing Tesla cars, which are currently driving on the road. This feature allows the Tesla cars to take control of the steering, braking and to switch lanes when needed. This feature however, assumes that the driver is available at any moment to take back the control of the car. By collecting the data of all Tesla drivers, Tesla can keep on improving and upgrading the Autopilot feature. And it does so, in October 2016 Tesla has announced that all vehicles in production will be equipped with new hardware that will allow the cars to drive fully autonomous.⁹ The technology is already there, now they only have to wait for the regulatory approval of fully autonomous cars...¹⁰

2.1.2 Unmanned aerial vehicles

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft with no pilot on board. The aircraft can either be remote-controlled (Remotely Piloted Aircraft or RPA) or can be guided through programming to fly fully autonomous in several missions. The term

⁶ SOLIS, B., The race the 2021: the state of autonomous vehicles and a who's who of industry drivers, <http://www.slideshare.net/Altimeter/the-race-to-2021-the-state-of-autonomous-vehicles-and-a-whos-who-of-industry-drivers> (consulted 14 February 2017).

⁷ Holding company of Google Inc.

⁸ C. MUI, *Waymo is crushing the field of driverless cars*, <http://www.forbes.com/sites/chunkamui/2017/02/08/waymo-is-crushing-it/#40d743866790> (consulted 15 February 2017).

⁹ C. THOMPSON, *Tesla just revealed new cars and Model 3 will have fully self-driving hardware*, <http://uk.businessinsider.com/tesla-announces-new-autopilot-self-driving-2016-10?r=US&IR=T> (consulted 15 February 2017).

¹⁰ F. LAMBERT, *Tesla's software timeline for 'Enhanced Autopilot' transition means 'Full Self-Driving Capability' as early as next year*, <https://electrek.co/2016/10/20/tesla-enhanced-autopilot-full-self-driving-capability/> (consulted 15 February 2017).

UAV includes the smaller consumer electronic aircrafts (which are free available on the market) as well as very large aircrafts.¹¹

An UAV can be equipped with systems to collect certain information and/or with weapon systems. The absence of human presence on board of these drones offers the possibility to carry out missions of longer duration and/or with a higher risk. Another advantage of the UAV is their low cost, especially in comparison to a traditional airplane.¹²

Therefore, UAV's are currently being used for multiple purposes; they are being used for performing military services, aircraft maintenance, aerial surveillance, commercial filmmaking, infrastructure maintenance, scientific research, and several other uses. Next to all these functions, the private use of drones has also increased in popularity.

Aside from the useful purposes of UAVs, a lot of objections rose with regard to the safety in the airspace, the safety of persons and properties on the ground and the protection of the privacy. Therefore, regulatory action was highly necessary.

The European Commission (EC) is aware of the emerging RPA market and the need for a harmonized regulation. In 2014, they have announced that they are working on a legislative proposal to remove legal uncertainties and to assure a high level of protection in terms of safety, security and privacy for the European citizens.¹³ The national authorities of European member states have the competence to regulate the use of drones below 150kg, whereas Europe keeps the competence to regulate the use of drones over 150kg. The EC is now preparing a regulatory framework in cooperation with different stakeholders, such as the European Aviation Safety Agency (EASA). The International Civil Aviation Organization (ICAO) is also preparing a regulatory framework for the use of UAV's.¹⁴

¹¹ M. DE GROOF, "Death from the Sky: International Legal and Practical Issues on the Use of Armed Drones" in A. ZAVRSNIK, *Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance*, Ljubljana, Springer, 2015, (131) 133.

¹² Ibid.

¹³ Communication (EC) to Council and EP, A new era for aviation: Opening the aviation market to the civil use of remotely piloted aircraft systems in a safe and sustainable manner, 8 April 2014, COM (2014)207 final.

¹⁴ P. MENDES DE LEON and B.I. SCOTT, "An Analysis of Unmanned Aircraft Systems Under Air Law" in A. ZAVRSNIK, *Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance*, Ljubljana, Springer, 2015, (185) 186.

To overcome the legal uncertainties regarding the use of drones several European member states have already adopted legislation. On 10 April 2016, Belgium has adopted a Royal Decree regarding the use of remotely piloted aircrafts in the Belgian Airspace¹⁵. This Royal Decree limits the use of RPA's in the Belgian airspace and installs different requirements for the pilot as well as the equipment of the RPA.

¹⁵ Royal Decree 10 April 2016 with regard to the use of remote-controlled aircrafts in the Belgian airspace, *BS* 15 April 2016.

2.2 The state of affairs of unmanned vessels

2.2.1 Introduction

After seeing how technology is evolving the industry of road and aerial vehicles, we will now get back to the subject matter of this paper; the unmanned vessels. In this part, I will discuss the different projects which are currently researching different aspects of unmanned shipping.

2.2.2 MUNIN

The European project MUNIN was a research study, funded by the EC, on the technical, economic and legal feasibility of the unmanned merchant shipping operations, which was carried out between 2012 and 2015. MUNIN is the abbreviation for Maritime Unmanned Navigation through Intelligence in Networks, which refers to the idea of MUNIN of developing a technology for unmanned vessels. The MUNIN project has emerged out of the strategic research agenda of Waterborne TP, which is a cluster of European stakeholders in the maritime affairs. Waterborne TP had published a paper on the vision of the development of the maritime industry in the future. In this paper, the autonomous vessel was named as one of the key proposals for the maritime European research agenda.¹⁶

The general goal of MUNIN was to develop and verify the concept of autonomous ships. To achieve this ultimate goal, a number of specific objectives were set out in the project:

- The development of a technologic concept required to implement the autonomous and unmanned ship;
- The development of essential integration mechanisms, which includes the ICT architecture and a blueprint for a cooperative procedure;
- The verification and validation of the concept through tests in different situations and critical situations;
- Documenting the required change in legislation and commercial contracts to allow the use of autonomous and unmanned ships;

¹⁶ MUNIN, *Research in maritime autonomous systems: Project results and technology potentials*, MUNIN, 2016, 1.

- Providing a thorough economic, legal and safety analysis showing the impact on the European shipping's competition and safety;
- Showing how the concept can give direct benefits and can provide advantages of efficiency, safety and sustainability for existing vessels in the short term.¹⁷

2.2.2.1 General results

In the MUNIN project they experimented on a dry bulk carrier of 75.000 dwt, operating in a long continuous deep-sea voyage, at a service speed of 16 knots. The part of the voyage in congested or shallow waters was not a part of the MUNIN project, because they believed that this part still will need to be executed by a crew on board of the vessel.

MUNIN proposed a concept whereby a ship operates autonomously by newly developed systems on board of the ship and whereby the monitoring and the controlling of the unmanned vessel is carried out in the SCC, which is the operator ashore. MUNIN has also defined several concepts, which are essential for unmanned shipping. For instance, an Advanced Sensor Module, taking care of the lookout duties on board, an Autonomous Navigation System, following a predefined voyage and capable to adapt the route autonomously according to the applicable legislation and the rules of good seamanship, and several other concepts.¹⁸

MUNIN also performed a cost-benefit analysis on the commercial viability of unmanned merchant shipping, compared to a conventional bulker as a reference point. MUNIN estimates that the unmanned bulk carrier would improve the expected present value by 7 million USD over a 25-year period and that autonomous ships have a high possibility of improving the profitability of shipping companies. Logically, the largest saving in cost is due to the saving in crew costs. Besides the saving in crew costs, MUNIN assumes the autonomous ship will allow for some changes in the ship design. These assumed innovative ship designs will have the benefit of some reduction in the consumption of fuels, and by consequence reducing emissions.¹⁹

¹⁷ X, *Munin's Objectives and Impact*, <http://www.unmanned-ship.org/munin/about/munins-objectives/> (consulted 20 February 2017).

¹⁸ MUNIN, *Research in maritime autonomous systems: Project results and technology potentials*, MUNIN, 2016, 2.

¹⁹ *Ibid*, 3.

The safety of autonomous vessels is also a matter that raises a lot of questions. MUNIN carried out a safety and security analysis on the autonomous vessel. Considering the fact that most of the maritime accidents are mainly or partly caused by human errors and fatigue issues in particular, MUNIN assumes that unmanned shipping will be ten times safer compared to manned shipping. MUNIN also expects a lower risk of engine and system breakdowns, provided that the ship follows an improved maintenance and monitoring scheme.²⁰ Applying this condition to manned ships, probably would increase the safety of manned ships as well.

However, unmanned vessels are not safer and more secure on all areas. MUNIN expresses the justified concern of possible threats of piracy and cyber-attacks to unmanned vessels. Whether the unmanned vessels are attractive to such attacks is still unclear, but software systems should nevertheless be designed with a very high resistance against such attacks.²¹

2.2.2.2 Legal results

The MUNIN project also carried out a legal feasibility assessment on the operation of unmanned vessels, even though it was rather limited. MUNIN concluded that the legal framework can be adapted to allow autonomous vessels in maritime transport, if unmanned vessels can at least sail as safe as a manned ship.

The most significant changes for unmanned vessels will be required on the present manning and navigation regulations. Next to this, MUNIN expects that the regulated standards regarding the construction, design and equipment of ships also will need an adaptation. And so, MUNIN decides that the unmanned ship is not an unsurmountable obstacle from a legal perspective.²²

In the liability analysis of unmanned ships, MUNIN means that the biggest issue will be how to attribute the duties of the ship master. In particular, the question arises which persons, involved in the operation of an unmanned vessel, are in the best position to carry out these duties. Should the legal role of the master be split up between the SCC operators²³ and masters, or should there be a separate entity created in the SCC to take care of the masters' duties? These

²⁰ Ibid.

²¹ Ibid.

²² Ibid.

²³ MUNIN defines the SCC operator as the person who monitors the safe operations of several autonomous ships from and can control the vessels by giving commands.

questions remain unanswered by MUNIN, but they recognize that further research is necessary.²⁴ This paper will try to do the necessary research on these matters.

2.2.3 ENABLE

The ENABLE-S3 project is also a European project, that was created to test, verify and validate the safety of autonomous vehicles in Europe. At first the project was solely focused on the safety of driverless cars. The EU has extended the scope of the project to the complete transport industry, because the project has the feeling that the automated and autonomous systems in different domains are facing the same challenges.²⁵ The ENABLE-S3 project has started in July 2016 and is expected to terminate in October 2019.

The ENABLE-S3 project has set up a consortium consisting of experts in six different domains (aerospace, automotive, farming, health, maritime and railway), together with tool suppliers and academics, to look for solutions for the main challenges of autonomous systems. The complete consortium exists of 71 partners (such as, Renault, Toyota, IBM, Siemens, Navtor, Airbus...) from 16 European countries. The size of the consortium enables the ENABLE-S3 project to have a large network of experts for verifying and validating autonomous systems in different areas, because with all the partners in the consortium, the project has a large coverage of the supply chain.²⁶

The main goal of the ENABLE-S3 project is to create cross-domain (semi-)virtual platforms and methodologies for automatic and controlled processes. The project wants to replace the current physical validation and verification methods, which take a lot of time. They want to install virtual testing and verification methods, while maintaining a high level of validity of the tests. Before integrating the models, methodologies and tools into a validation platform, they will be applied in several use cases (different environments and scenarios), where they will be validated.²⁷

²⁴ MUNIN, *Research in maritime autonomous systems: Project results and technology potentials*, MUNIN, 2016, 3.

²⁵ X, *NAVATOR takes maritime lead for EU autonomous vessel project*, <http://www.transport-research.info/news/navtor-takes-maritime-lead-eu-autonomous-vessel-project> (consulted 28 February 2017)

²⁶ X, *Consortium*, <http://www.enable-s3.eu/about-project/consortium/> (consulted 28 February 2017)

²⁷ <http://www.enable-s3.eu/about-project/> (consulted at 28 February 2017).

The ENABLE-S3 project has published several of their technical objectives. These are:

- To provide a framework for the verification and validation of the automatic and controlled processes, which requires at least 50% less effort than the traditional testing.
- To promote a new technique for testing of automated systems with physical sensor generators.
- To raise the level of trustworthiness of the automated systems, by providing a holistic verification and validation platform, which will lead to a reduction of the probability of malfunction behaviour.
- To provide an environment for validating a faster re-qualification.
- To create open standards in order to accelerate the adoption of new validation tools and methods.
- To enable safe, secure and functional automatic and controlled processes across the six different domains.
- To create an eco-system for validating and verifying the automated systems in the European industry.²⁸

As one will notice, the ENABLE-S3 is strongly focused on the technologic aspect of autonomous vehicles. It looks at improving the technological process in the development of the systems autonomous vehicles. The project is still in its first phase, and no results have been published so far. Due to the fact that the project doesn't handle any legal challenges of autonomous vehicles, the details of the project will not be handled further in this paper.

2.2.4 The Advanced Autonomous Waterborne Applications Initiative

The Advanced Autonomous Waterborne Applications Initiative (AAWA) is a project, leaded by Rolls-Royce, to explore the economic, technical, legal and social challenges that need to be handled before the autonomous shipping can become reality. The AAWA Initiative is funded by Tekes²⁹. The AAWA project is executed by a cooperation of Finnish universities³⁰ and a

²⁸ Ibid.

²⁹ i.e. the Finnish Funding Agency for Technology and Innovation.

³⁰ Tampere University of Technology; Abo Akademi University; Aalto University; University of Turku.

research centre³¹ on the one hand, and stakeholders active in the maritime business on the other hand³². The project kicked off in 2015 and runs until the end of 2017.³³

The goal of AAWA is to develop the specifications and preliminary designs of the remote-controlled or fully autonomous vessels. Next to this goal, AAWA looks at a business model for unmanned shipping companies, researches the possible safety and security issues of unmanned ships, investigates the legal and regulatory implications and analyses the readiness of the supply chain networks.³⁴

In particular, AAWA has tried to create an answer to the following questions;

- What technology is needed for unmanned ships and what is the best option in which a vessel can sail autonomously at a great distance from the shore?
- In what way can the unmanned vessels be at least as safe as the crewed vessels, what are the (new) risks they are going to face and how can these risks be eliminated?
- What incentives will shipowners and operators require in order to invest in autonomous ships?
- Will unmanned ships be considered as legal ships and who will bear the liability in the case of an accident?

In the first phase of the project, AAWA has examined the trend of remote-controlled and autonomous transport in other transport modes (driverless cars and UAV's) and looked at the current technological, economic, legal and safety state of the maritime industry with regard to unmanned shipping, and how the ideas of the other transport modes can be transferred to the shipping industry. The second and third phase of the AAWA project will be based on the results from the first phase to develop the technical, legal and safety specifications. The results of these phases are expected to be finished at the end of 2017.³⁵

³¹ VTT Technical Research Centre of Finland Ltd.

³² Rolls-Royce; the classification society DNV GL; the mobile satellite company Inmarsat; ship design company Deltamarin; naval software company NAPA; wireless connectivity company Brighthouse Intelligence; ferry company Finferries; and shipping company ESL Shipping.

³³ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 5-6.

³⁴ *Ibid*, 6.

³⁵ *Ibid*.

The results of the first phase of AAWA will be discussed in a general way in this paper. The results about the legal challenges will be incorporated more profoundly in this paper.

2.2.4.1 General results of the 1st phase

First of all, AAWA believes that there will not be a single solution between the choice of remote-controlled vessels or autonomous vessels. AAWA believes they both will be operating, and the choice will be dependent on the type of vessel and the exact function of the vessel. For instance, when the ship has to operate in more complex and various missions, the remote-control option probably will be the better choice. But when a ship has to sail on a long deep sea voyage, the level of autonomy of the ship probably will be much higher.³⁶

Secondly, AAWA has concluded that the required technologies to make unmanned ships possible, already exists. The remaining issue however, is to find a way how to combine these technologies, so the ship is able to operate in a reliable and cost-efficient manner. Finding this optimal manner of operation will require a thorough research process through several tests and simulations.

Thirdly, AAWA comes to the conclusion that the unmanned ships will be able to operate at least as safe as the current manned vessels.³⁷ Unmanned vessels will certainly not be more dangerous than the manned vessels, because the main cause of maritime accidents (i.e. human errors) will be eliminated due to the higher level of automatization in unmanned vessels.³⁸ Human errors may still occur in case of remote-controlled vessels, but presumably they will occur less frequently compared to the existing vessels.

On the other hand, AAWA did not jump to the conclusion that unmanned shipping will be safer and more secure as such, because of the uncertainty concerning new risks and dangers. From the point of view of security, concerns have been expressed about the higher vulnerability to cyber-attacks, which could enable hackers to illegally manipulate and operate the system.

³⁶ Ibid, 12-13.

³⁷ Ibid, 13.

³⁸ Ibid, 60.

Further, it is also uncertain what effect the unmanned vessels will have on the hijacking and piracy of ships.³⁹ All these new hazards and risks still need to be identified and assessed.

The fourth initial statement concluded by AAWA is that the unmanned ships have the possibility to revolutionize the maritime industry. The different players in the maritime industry will be influenced largely by the launching of the unmanned vessels, especially the roles of shipping companies, shipbuilders, maritime software and hardware providers, and even technology companies from other sectors will be renewed.⁴⁰

2.2.4.2 Legal results of the 1st phase

In this part, a summary will be given on the legal results of the AAWA project. The more detailed findings of AAWA will be incorporated further on in this paper, more precisely in the part on the legal challenges.

The existing maritime law is not foreseen on the launch of unmanned vessels. In order for the unmanned vessels to become a reality, there is no doubt about it that action is required on all regulatory levels. IMO will need to make some amends in the IMO conventions, as well as the regulatory authorities on the national levels will need to adapt their legislation. Of course, a political will is necessary for this regulatory effort.

AAWA recommends that IMO should take the lead in adapting the regulations to the needs of unmanned shipping. First of all, because the technical IMO rules create the most conflicts with unmanned ships. Secondly because the IMO treaties form the dominant and primary maritime regulation; these rules will be used as a guide for the changes in the jurisdictional rules of the law of the sea and the changes in the national maritime laws.⁴¹

AAWA also advises that regulatory authorities better make a distinction, according to the degree of automatization. This is because fully autonomous ships are a bigger legal challenge, than remote-controlled ships. Because the remote-controlled ships still will have a crew, it will

³⁹ Ibid.

⁴⁰ Ibid, 13.

⁴¹ Ibid, 54.

be easier to comply with some of the existing operating rules, even if the crew is not on board of the ship.⁴²

AAWA has also researched the maritime liability rules. Despite the fact that they probably will undergo some serious changes, the changes in maritime liability legislation are less urgent. AAWA proposes that the existing maritime liability rules can be interpreted, amended or supplemented to deal with the challenges of unmanned shipping. The new liability rules and other liability rules, such as product liability, are expected to affect the marine insurance policies and other business relationships of shipowners and ship operators. What the exact influence will be is also a matter that still needs to be researched.

The conclusion by the AAWA project on the legal aspect of unmanned vessels is that the regulatory challenges are not unsurmountable. However, according to AAWA, the main issue concerns the political and societal will to embrace the unmanned vessels and to cope with the legal challenges. The social acceptance and readiness of the maritime community and regulatory authorities will be the key issues to accommodate unmanned shipping. If they are ready to accept unmanned shipping, the only challenge left, is to identify the regulations that are in need of adjustments, and install the amendments.⁴³

AAWA realizes that it takes several years to initiate and formulate new international amendments, and yet some more years in order for amendments to come into effect. In the meantime, IMO guidelines or best practice codes for unmanned shipping operations would be the best option for guiding and assisting flag states who wish to support unmanned shipping, but are still awaiting for international regulations, which is usually the case in maritime law.⁴⁴

2.2.4.3 Next steps

The next phases will be based on the results of the first phase to develop the technical, legal and safety characteristics. In particular, AAWA has planned to explore the following:

⁴² Ibid.

⁴³ Ibid, 55.

⁴⁴ Ibid.

- Developing and testing the specific technological resolutions for autonomous operations, through the use of simulators and tests at sea in different operating and climatic conditions.
- Carrying out the research to analyse the changed and new risks that come with unmanned shipping and consequently creating a new approach, based on systematic and extensive risk assessments.
- Exploring the legal challenges of operating an unmanned vessel, on the national level as well as looking into the required changes of the IMO rules.
- Exploring the opinions and meanings of the different stakeholders of unmanned shipping to work out the cost and revenue balances of remote-controlled and autonomous shipping, for different types of ships.

The results of these next phases are expected at the end of 2017. AAWA expects the first remote-controlled ships to be in commercial use by 2020.⁴⁵

2.2.5 RAVEN

RAVEN (Remote-controlled and Autonomous Vessels for European and National waters) was the name of the international project between the Flemish waterway managers⁴⁶, the University of Leuven and the Norwegian company Marintek. The purpose of the RAVEN project was to examine whether unmanned vessels could be used on Flemish waterways and to what extent that this would be economically viable.

RAVEN intended to transform an existing ship into an autonomous ship that would be able to carry goods. It would also research how the infrastructure ashore should be adapted for new technologies and how the berthing and docking procedures should be carried out. Next to the technical challenges, the project would check which legislations should be adapted to make unmanned shipping legal on Flemish waterways. The ultimate goal of the project was to have one unmanned vessel sailing in Flanders as a real test.⁴⁷

⁴⁵ Ibid., 14.

⁴⁶ Waterwegen en Zeekanaal NV and NV De Scheepvaart

⁴⁷ <https://www.vlaamsparlament.be/commissies/commissievergaderingen/1065930/verslag/1069220> (consulted 15 March 2017).

The writing in past tense already reveals the disappointing news; the promising project did not receive the required funding from Europe. As of today, some other interesting projects are being researched in Flanders.⁴⁸

2.2.6 CMI

CMI (Comité Maritime International) is the non-governmental international organization with the purpose to contribute by all appropriate means to the unification of maritime law in all its aspects. They have been involved in the drafting of different international conventions and regulations over the past 100 years.⁴⁹ As they realize that the interest in autonomous shipping is increasing, they have set up a working group. This CMI working group has the purpose to make sure that all regulations are in place for when unmanned vessels would come at sea.⁵⁰

⁴⁸ X, *Geen Europese steun voor Vlaams proefproject onbemand varen*, <http://nl.metrotime.be/2017/03/07/news/geen-europese-steun-voor-vlaams-proefproject-onbemand-varen/> (consulted 15 March 2017).

⁴⁹ <http://comitemaritime.org> (consulted 12 May 2017).

⁵⁰ <http://comitemaritime.org/Maritime-Law-for-Unmanned-Craft/0,27153,115332,00.html> (consulted 12 May 2017).

Part 3 Opportunities and obstacles

3.1 Opportunities and benefits

Unmanned shipping is considered as a trending topic for the future of maritime transport with a number of benefits for shipowners, the shipping industry, the environment, etc. This section of the paper will briefly give an overview of different opportunities and benefits of unmanned shipping, from different points of view. Logically, most of these benefits are direct consequences of the absence of a crew on board of the vessel.

The first and the most popular benefit is the cost savings in crew wages. To sail an unmanned vessel, there is no crew required aboard the ship. So, the shipowner can save on crew costs, which generally can take up between 30% - 60% of a ships' operating costs, depending on the nationality. Also in the construction of the ship, savings can be made due to the fact that there is no need for superstructures to support the human navigation and accommodation infrastructures.⁵¹

When there still is a crew working ashore to supervise and control the vessel, the amount of required personnel will be less, and their wages are estimated to be lower, because the crew doesn't need the statute of seafarers. They do not incur the risks of a 'maritime adventure'. The crew doesn't necessarily have to be long away from home, and so they can work in different shifts within regular working periods of 8 hours.

It is also plausible that the people working in a SCC are in control of several vessels at once. Therefore, shipowners could have the possibility to split the costs of the wages of the people working in a SCC. In the case of autonomous vessels, the crew cost will be reduced even more. However, it should be noted that the savings in crew costs may be balanced by the costs of investing in the new expensive technologies.⁵²

The second most important advantage of autonomous shipping will be the reducing of fuel consumption and emissions. Due to the automation, unmanned ships will be able to sail more

⁵¹ P.W. PRITCHETT, "Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology", *Tulane Maritime Law Journal* 2015, (197) 201.

⁵² A.-S. PAUWELYN, *Autonom varen: de crew aan wal*, Personal correspondence, 2017, 6-9

efficient, and consume less fuel, and reducing the fuel emissions.⁵³ What's more, ships will become lighter, because they don't need accommodation infrastructures on board, which will also result in less fuel consumption.

Another cost reducing effect of autonomous shipping can be induced due to the availability of data. The amount of available data will increase with unmanned ships. If the different stakeholders of the maritime transport and port industry decide to cooperate, they could reduce costs. Shipowners, terminal operators, bridge-, lock-, cargo handlers and other stakeholders could tune their schedules to each other, depending whereto and how fast the cargo is travelling, by exchanging the information they own.⁵⁴

As said before, the human error is one of the main causal factors of maritime accidents. The replacement of the crew's duties by automated navigation and lookout systems, will definitely decrease the amount of human errors. Hereby, the overall safety of shipping will increase largely.

Unmanned ships are also expected to be less polluting than the traditional ships. As an indirect result of the unmanned vessel, vessels can become greener due to the practice of slow steaming. With a reduction of 30% in the speed of a vessel, a vessel can save up to 50% in fuel consumption, even when taking into the account the fuel required for a longer journey. Slow steaming is not a new concept anymore, but slow steaming was not interesting up till now, because the savings in fuel costs, would not outweigh the increased costs of crew wages.⁵⁵

Unmanned ships are supposed to be able to operate in a more efficient way, due to more efficient energy management systems and improved navigation and routing systems. Above this, the absence of superstructures, such as the deckhouse and accommodation rooms, will make the ship more aerodynamic. This will decrease the total resistance of a ship, and consequently increase efficiency, and thus resulting in a decrease of fuel consumption and operating costs.

⁵³ Ibid.

⁵⁴X, *Autonom varen mogelijk antwoord op dreigend personeelstekort in de scheepvaart*, <http://www.tudelft.nl/nl/actueel/laatste-nieuws/artikel/detail/autonom-varen-mogelijk-antwoord-op-dreigend-personeelstekort-in-de-scheepvaart/> (consulted 9 March 2017).

⁵⁵ MUNIN, *Research in maritime autonomous systems: Project results and technology potentials*, MUNIN, 2016, 5.

Other advantages:

- No accidents aboard ships;
- Solution for the impending seafarer shortage;
- More space available for cargo holds;
- Newly built unmanned vessels will deliver an enormous stream of data. This data will enable shipowners to manage their fleet in an optimal way. That is because, shipowners will be able to look at the collective data of all their ships together in order to establish the best combination of route, cargo, fuel price and maintenance schedule for their complete fleet. In that way, they can get the maximum value out of their fleet.⁵⁶

3.2 Obstacles and disadvantages

However, not every aspect of unmanned shipping is all roses. New hazards and risks will emerge with the remote-controlled and autonomous vessels. In this sector, I will give an overview of the disadvantages and limitations of unmanned shipping, which are likely to take place. Yet, not all the risks and disadvantages are known today. The knowledge of possible risks will still increase through comprehensive analyses, simulator tests, and the demonstrating tests and studies on actual seagoing vessels.⁵⁷

As mentioned before, unmanned vessels have the disadvantage that they may be more vulnerable to piracy with the purpose of stealing the cargo or hijacking the vessel for a ransom. It is also credible, that there will appear a new type of piracy, executed as cyber-attacks, that would allow *hackers-pirates* to illegally take over the remote-control system of the vessel. Therefore, the ICT systems of vessels will require a higher level of security than today to withstand these cyber-attacks, which may be attempted via the ICT infrastructures.

Because, in case of unmanned ships, these *hackers-pirates* would be able to overtake control of the vessel and could change the direction of the vessel. Such overtaking could go from just annoying with disturbing actions and manoeuvres to hijacking the vessel and cargo, or inducing

⁵⁶ AAWA, *Remote and Autonomous Ships: The next steps*, Rolls-Royce plc, London, 2016, 5.

⁵⁷ *Ibid*, 58.

the ship to ground or collide with other (crewed) vessels. The disastrous consequences of overtaking the ICT system could happen easily without sufficient security.⁵⁸

The remote operation and monitoring of the unmanned vessels, can also bear some obstacles with them. First of all, the AAWA project has expressed a concern, that there will be a lack of bodily feeling, so the full understanding of the vessel will not be achieved by the use of camera systems.⁵⁹ However, the use of sensor systems can increase the complete understanding of the vessel movements.

A second unfavourable consequence is that there could exist an overload of data due to the large number of sensors installed on the vessel. An overload of information could create a dangerous situation when the operator loses the ability to make sense of the whole situation, and fails to control of the vessel. The probability of such situation becomes even higher when there is only one person monitoring and controlling several vessels at once. A possible solution is to have a software installed that can process the signals of all the sensors, in a way that the complete system becomes clear and transparent for the operator.⁶⁰

The unmanned vessels could also have a negative effect with regard to the skills of seafarers. Especially in the long term, there is a risk that there will a skill shortage and a degradation of skills. Due to the higher dependency on the automation of the vessel, it will become difficult to maintain all the practical skills of a maritime journey. Forgetting these skills, can become dangerous, especially in emergency situations, for instance when there is a malfunction in the remote controlling system and persons need to intervene.

Currently the activity of loading and stowing the cargo on board in ships is executed by the ship's master and the first officer. With unmanned vessels, these persons will no longer be on board. Possibly, it will become a task of port operators to perform the loading and unloading of the cargo, and to assure that the cargo is correctly stowed on board. However, transferring these risks to another party doesn't go without any risk.

⁵⁸ Ibid, 66.

⁵⁹ Ibid, 64.

⁶⁰ Ibid, 64.

AAWA for instance, believes that this could increase the risk of cargo-related incidents. That is because, the crew and officers of traditional vessels have a personal incentive to assure the correct loading and stowing of the cargo. Port operators would not have this incentive, and may execute these tasks less careful. This issue could be solved by also transferring the risk of liability together with the execution of the tasks.

Another challenge that needs to be handled when controlling the unmanned vessels remotely is the latency of the teleoperation system. Latency is the period of time it takes for a signal, expressed by the operator, to reach the vessel via satellites or other means. If the latency becomes too long, this could jeopardize the safe and efficient operation of the vessel.⁶¹

Another risk factor to take into account is the boredom of the vessel operators. In a study on the operators of UAS, the results showed that 92 % of UAS operators reported they suffered from moderate to total boredom. The boredom of the operator could eventually end in a loss of vigilance, with a negative influence on the overall abilities of the vessel operator.⁶²

A more human issue that will form a challenge in the future is the amount of job losses. Currently, the international shipping industry employs 1,545,000 seafarers and the global demand for seafarers still is increasing.⁶³ With unmanned shipping, this amount is likely to decrease rather slowly, as the traditional vessels will be slowly replaced by unmanned vessels. But with unmanned vessels, there still will be other types of jobs, such as remote controllers, IT engineers, maintenance crew, ... So, what the real effect will be on employment is still uncertain.

⁶¹ Ibid.

⁶² Ibid, 65.

⁶³ UNCTAD, *Review of maritime transport 2016*, Geneva, UN Publication, 2016, 44.

Part 4 Legal challenges

What are the legal challenges for autonomous and remote-controlled shipping? Is the current maritime law (partly) compatible or is there a need for adaptation, in order to make unmanned shipping possible? In what way do some rules or conventions need to be amended to let those legal issues dissolve? This part of the thesis will handle all these question, and forms the core part of the thesis. The compliance of the unmanned vessels will be analysed with maritime law in the broad sense, so the public law of the sea and maritime law, as well as the private maritime law.

4.1 No crew, no ship?

When looking at the legal status of unmanned vessels, the first question that arises is, under what regime do the unmanned vessels fall? The relevance of this question has to do with the fact that ships, can profit from the benefits and rights established in maritime conventions. If an unmanned vessel is considered to be a ship, it must comply with the duties in existing regulations and it can benefit from the established rights in international conventions, such as, the right of innocent passage, freedom of the high seas, limitation of liability, uniform standards... If an unmanned ship cannot be considered as a ship, it is uncertain if it still can benefit from these rights.⁶⁴

To be able to define whether unmanned ships fall under the regime of maritime law, we need to look at the scopes of application of different maritime conventions. In particular, we need to look at the definitions of the term ‘ship’, to determine if a ship without a crew on board, still can be regarded as a ship. But, despite the fact that a ‘ship’ is the main object of various conventions and laws, there is no uniform international definition of a ship. The meaning of what can be defined as a ship rather depends on the scope of the distinct conventions and laws.⁶⁵

4.1.1 International definitions

⁶⁴ R. VEAL, *Unmanned ships and navigation: the regulatory framework*, Genova, IUMI, 2016, 9.

⁶⁵ W. TETLEY, *International Maritime and Admiralty Law*, Cowansville, Editions Y. Blais, 2002, 33.

First of all, the law of the sea lacks a definition for a ship (or vessel). The United Nations Convention on the Law of the Sea⁶⁶, sometimes referred to as ‘the constitution for the oceans’, does not even have a definition for a ship. Yet, this convention is highly important for the navigational rights and duties of ships. This may be one of the reasons why, most authors believe that unmanned ships will be assimilated to ships for the application of the law of the sea. Following this vision, unmanned vessels can enjoy the rights and freedoms and must comply with the applicable duties, that are similar to those applying to traditional ships.⁶⁷ This view must be supported, because there is no indication in the UNCLOS, that the presence of a crew would be an essential element to speak of a ship. Thus, the UNCLOS rules, defining the rights and duties of states, with regard to international shipping, will also apply to unmanned ships.

Also, several other multilateral conventions related to different matters of maritime law do not exclude their scope of application to ships with the presence of seafarers. Most of these conventions have their own definition, adjusted to the specific topic they handle.⁶⁸

First of all, according to The Hague Rules⁶⁹ a ship means “*any vessel used for the carriage of goods by sea*”, and according to the Athens Convention⁷⁰ a ship means “*only a sea going vessel, excluding an air-cushion vehicle*”. These definitions, each adapted to their respective topic, do not form any obstacle to the application of unmanned vessel.

The International Convention for the Prevention of Pollution from Ships (MARPOL)⁷¹, for example, defines a ship as “*a vessel of any type whatsoever, operating in the marine environment and includes hydrofoil boat, air-cushion vehicles, submersibles, floating craft and fixed or floating platforms*”⁷². It is clear that a broad definition like this one would also include

⁶⁶ United Nations Convention on the Law of the Sea, Montego Bay, 10 December 1982. (hereafter: UNCLOS)

⁶⁷ J. KRASKA, “The law of unmanned naval systems in war and peace”, *The Journal of Ocean Technology* 2010, vol. 5, (43) 51-52.

⁶⁸ E. VAN HOOYDONK, “The law of unmanned merchant shipping”, *The Journal of International Maritime Law*, 2014, (403) 406.

⁶⁹ International Convention for the Unification of Certain Rules of Law relating to Bills of Lading, Brussels, 25 August 1924 (hereafter: The Hague Rules).

⁷⁰ Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, Athens, 13 December 1974.

⁷¹ International Convention for the Prevention of Pollution from Ships, London, 2 November 1973 (hereafter: MARPOL).

⁷² Art. 2.4 MARPOL.

unmanned vessels. The convention related to the civil liability for oil pollution damage seem to have a similar definition. The CLC Convention⁷³ namely defines a ship as: “*a sea-going vessel and seaborne craft of any type whatsoever constructed or adapted for the carriage of oil in bulk as cargo, provided that a ship capable of carrying oil and other cargoes shall be regarded as a ship only when it is actually carrying oil in bulk as cargo and during any voyage following such carriage unless it is proved that it has no residues of such carriage of oil in bulk aboard*”.⁷⁴ This definition is more customized to the application scope of the CLC Convention, but still, any unmanned vessel carrying oil can fall under this definition. The London Dumping Convention⁷⁵ foresees another definition. Vessels and aircrafts can be a “*waterborne or airborne craft of any type whatsoever. This includes air cushioned craft and floating craft, whether self-propelled or not*”.⁷⁶

The UN Convention on Conditions for the Registration of Ships⁷⁷ has also defined the ship, but hasn't come into force yet. It defines ships as “*any self-propelled sea-going vessel used in international seaborne trade for the transport of goods, passengers, or both with the exception of vessels of less than 500 gross registered tons*”. Again, this does not exclude unmanned vessels from the application scope. The International Collision Regulations (COLREGs)⁷⁸ is another convention that provides a definition for a ship and stipulates that a vessel includes “*every description of water craft, including non-displacement craft, WIG⁷⁹ craft and seaplanes, used or capable of being used as a means of transportation on water*”.⁸⁰ Clearly, the characteristics of an unmanned vessel will also fit under this definition. A similar definition of what a vessel is, can also be found in the Salvage Convention.⁸¹

A large number of other conventions, related to private maritime law, are applicable to seagoing ships, but do not provide any definition of what can be defined as a ship. The Collision

⁷³ International Convention on Civil Liability for Oil Pollution Damage, Brussels, 29 November 1969, as amended by the 1992 Protocol (hereafter: CLC Convention).

⁷⁴ Art. 1.2 CLC Convention.

⁷⁵ Convention on The Prevention of Marine Pollution by Dumping of Wastes And Other Matter, London, 19 December 1972 (hereafter: London Convention).

⁷⁶ Art. 3.1 London Convention.

⁷⁷ United Nations Convention on Conditions for Registration of Ships, Geneva, 7 February 1986.

⁷⁸ Convention on the International Regulations for Preventing Collisions at Sea, London, 20 October 1972 (hereafter: COLREGs).

⁷⁹ Wing-in-ground craft, able to operate above the surface due to an aerodynamic lift.

⁸⁰ Rule 3(a) COLREGs.

⁸¹ International Convention on Salvage, London, 28 April 1989.

Convention⁸², the Ship's Arrest Convention⁸³, the LLMC Convention⁸⁴ are just some of the examples of international conventions, applicable to vessels, without any definition.

An extensive overview of all the definitions in all the international conventions linked to maritime law, clearly would lead us too far. The different definitions of “ships” and “vessels” differ slightly, mostly in function of the subject matter concerned in the convention. The variations in the definitions only depend on the field of waterborne devices the conventions want to regulate.⁸⁵ In the above selected conventions, having a crew on board is not a requirement in any of the definitions, so there is no convention that would exclude the application of unmanned vessels. It can be assumed that this is the case in all the international maritime conventions. Thus, unmanned vessels will be entitled to all the same rights and will be responsible to execute all the same duties, as the traditional manned vessels.

4.1.2 National definitions

It is already clear that under the international maritime law, an unmanned vessel will be assimilated to the crewed vessels, and they will fall under the same international regimes. To determine whether this is also the case in the national maritime legislation, we will look at different definitions from several national legislations.

In the United States the standard definition of a “vessel” stipulates that “*a vessel is every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water*”.⁸⁶ Identical definitions are being used in several other acts, such as the Deepwater Port Act of 1974, the International Navigational Rules Act of 1977, and in the Oil Pollution act of 1990⁸⁷. According to this definition, an unmanned vessel will be regarded as a vessel.

⁸² Convention for the Unification of Certain Rules of Law with respect to Collisions between Vessels, Brussels, 23 September 1910.

⁸³ International Convention on the Arrest of Ships, Geneva, 12 March 1999.

⁸⁴ Convention on Limitation of Liability for Maritime Claims, London, 19 November 1976.

⁸⁵ W. TETLEY, *International Maritime and Admiralty Law*, Cowansville, Editions Y. Blais, 2002, 35.

⁸⁶ Sect. 3 Rules of Construction U.S.C.

⁸⁷ W. TETLEY, *International Maritime and Admiralty Law*, Cowansville, Editions Y. Blais, 2002, 36.

When there still would be discussion whether a certain craft can be qualified as a vessel or not, the American courts have developed the ‘purpose-test’ to decide what a vessel is. This test analyses (1) whether the structure is mobile and capable of being transported across water; (2) whether it is subject to the perils of the sea; (3) whether the structure is designed to be permanently to fixed in position; and (4) whether the status of the vessel is consistent with statutory or other policy considerations.⁸⁸ If the question about unmanned vessels would be asked to an American Court following this ‘purpose-test’, it would most likely result in 4 positive answers, with the conclusion that an unmanned vessel also is a vessel.

The United Kingdom has an even more basic definition of what a vessel is. According to the Merchant Shipping Act of 1995, a vessel is “*any ship or boat, or any other description of vessel used in navigation*”.⁸⁹ In the French jurisprudence, a ship is defined as a “*floating, moveable craft designed for ocean navigation*”.⁹⁰ In the Dutch Civil Code, ships are “*all things, that are no aircraft, and that are due to their construction destined to float and are floating or have been floating*”.⁹¹ The Navigation Act of Spain makes a distinction between a ship and a vessel. A ship is defined as “*any vehicle with the structure and capacity to sail on the sea to transport individuals or things, which has a full deck and a length equal to or greater than 24 metres*”. A vessel on the other hand, lacks a full deck and has a length below 24 metres.⁹²

For the application of the Belgian Maritime Code, sea-going vessels are considered as all sailing crafts of at least 25 tons, destined or commonly used for passenger or cargo transportation, fishery, towing, or any other lucrative activity at sea.⁹³ The Belgian Commission of Maritime Law has also prepared a draft version for a new Belgian Merchant Shipping Code. In the draft version, which also is founded on an extensive comparative law research, a new definition is stipulated.⁹⁴ It states that a ship is “*every craft, with or without its own propulsive power, with or without displacement, that floats or has floated and that is used or which is suitable for use as means of traffic on the water, including air-cushion craft but to the exclusion of fixed devices, waterplanes and amphibious vehicles*”.

⁸⁸ T.J. SCHOENBAUM, *Admiralty and Maritime Law*, St. Paul, West, 2001, 96-101.

⁸⁹ Sect. 255 U.K. Merchant Shipping Act 1995.

⁹⁰ R. RODIÈRE and E. DU PONTAVICE, *Droit Maritime*, Paris, Dalloz, 1997, 31.

⁹¹ Art. 8:1.1 Dutch Civil Code.

⁹² Art. 56-57 Spanish Act on Maritime Navigation, 24 July 2014.

⁹³ Art. 1 Maritime Code 21 August 1879, *OJ* 4 September 1879.

⁹⁴ E. Van HOOYDONK, “The law of unmanned merchant shipping”, *The Journal of International Maritime Law* 2014, (403) 408.

This list of the different national definitions and explanations of what a ship is could go on for several pages. But this is not the purpose of this chapter. The purpose is to show that clearly, an unmanned ship will be qualified like any other ship. All these definitions, one more comprehensive than the others, only differ slightly. But the one thing about these definitions that is certain, and that is relevant for the unmanned ships; none of these definitions mentions anything about having a crew on board. Hence, the presence of a crew is not an essential element of a ship. Therefore, unmanned ships fall under the definition of a ship, and consequently, the unmanned ships will be subject to the existing international conventions and national laws.

4.2 The Law of the Sea

The United Nations Convention on the Law of the Sea (UNCLOS)⁹⁵, concluded in 1982, is the foundation of the current applicable Law of the Sea. As a great achievement of international law and due to its comprehensiveness, it is righteously called the ‘constitution of the seas’. The UNCLOS deals with a number of issues that previous conventions had been unable to settle. For instance, the UNCLOS introduced innovative concepts such as the exclusive economic zone (EEZ) and the deep seabed, installed new obligations such as protection of marine environment, and created new institutions such as the International Tribunal for the Law of the Sea (ITLOS).⁹⁶

UNCLOS is represented as a “package deal”, according to which states are required to accept all of its provisions, because the rights and duties of flag, port and coastal states are designed in a balanced way. Due to the fact that unmanned vessels can be qualified as a ship in the sense of UNCLOS, they will also enjoy the rights of UNCLOS. Unmanned ships will be fully able to enjoy the navigational rights such as, the freedom of navigation on the high seas and EEZ and the right of innocent passage in the territorial sea.⁹⁷

AAWA also thinks that different rules for two ships (one with a crew and one without) would be unjustified, provided that the two ships are carrying out the same tasks and need to withstand the same dangers.⁹⁸

Off course, being subject to the same rules, also means that unmanned ships need to be in compliance with the same duties as conventional ships.

However, 35 years after the conclusion of the “constitution of the seas” it is no wonder that a large number of new issues and challenges have arisen. One of these future challenges are the unmanned vessels. When looking at unmanned vessels, the question arises how these vessels and their flag states will handle some of the duties stipulated in the UNCLOS. In particular, we will analyse the duties of flag states and ships that will become more difficult to fulfil including the requirement of the genuine link.

⁹⁵ United Nations Convention on the Law of the Sea, Montego Bay, 1982.

⁹⁶ D. FREESTONE, R. BARNES and D. ONG, *The Law of The Sea: Progress and Prospects*, New York, Oxford University Press, 2006, 1.

⁹⁷ J. KRASKA, “The law of unmanned naval systems in war and peace”, *The Journal of Ocean Technology* 2010, vol. 5, (43) 54-57.

⁹⁸ AAWA, *Remote and Autonomous Ships: The next steps*, Rolls-Royce plc, London, 2016, 37.

4.2.1 Duties of the flag state

The high seas are governed by the principle of the freedom of the high seas.⁹⁹ This means that the high seas are free from national jurisdiction and there is freedom of activities on the high seas, within the boundaries of international law.¹⁰⁰ A necessary corollary of this principle is the principle of the exclusive jurisdiction of the flag state. This means that the flag state has the exclusive enforcement and legislative jurisdiction over the vessels flying its flag.¹⁰¹

The freedom of the high seas comes together with the fact that there is no authority governing the high sea and there is no national jurisdiction applied on the high seas. But the legal order at the high seas still needs to be maintained. The principle of exclusive jurisdiction of the flag state takes care of this. First of all, the exclusive jurisdiction prevents any intervention on the vessel by states other than the flag state, which guarantees the freedom of activity of the vessel. Secondly, this principle transfers the responsibility to the flag state to ensure that vessels, flying their flag, are in compliance with the applicable international and national laws.

Art. 94 UNCLOS mentions the duties that fall under the responsibility of the flag state. It stipulates that every state needs to effectively exercise its jurisdiction and control in administrative, technical and social matters.¹⁰² Also, every state needs to take the necessary measures for ships flying its flag, to ensure safety at sea, with regard to *inter alia* “the construction, equipment and seaworthiness of ships” and “the manning of ships, labour conditions and the training of crew, taking into account the applicable international instruments”.¹⁰³

Art. 94 UNCLOS goes on by stipulating what these necessary measures should exist of. One of these measures a state must take is “to ensure that each ship is in the charge of a master and officers who possesses appropriate qualifications, in particular in seamanship, navigation,

⁹⁹ Art 87 UNCLOS.

¹⁰⁰ Y. TANAKA, *The International Law of The Sea*, Cambridge, Cambridge University Press, 2015, 156.

¹⁰¹ Art. 92 UNCLOS.

¹⁰² Art. 94 (1) UNCLOS

¹⁰³ Art. 94 (3) UNCLOS

*communications and marine engineering, and that the crew is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship”.*¹⁰⁴

Obviously, these duties of flag states were adopted in 1982 and designed for conventional ships, with a master and his crew. These requirements could lead to some serious difficulties for unmanned ships. The interpretation of these provisions with regard to unmanned ships leads to some questions. Different interpretations are possible:

- The most extreme interpretation would be that unmanned ships are illegal due to the fact that there is no master and officers on board who possess the appropriate qualifications. The flag state then has the responsibility to prohibit the unmanned ships. This would be the most archaic interpretation and would not be preferable to adopt.
- A possible solution would be that these duties will become obsolete, because there is no reason anymore for the master and officers being in charge of an unmanned ship. Therefore, the provision relating to this specific duty would become unapplied. This interpretation would certainly be the most interesting one for unmanned ship, and autonomous ships in particular.
- Another possible solution is that these duties would be interpreted by analogy on a SCC. In this interpretation, the operator of the ship would be considered as the master of the ship, and he would need to fulfil the duties and requirements of a master. But, the tasks of a shore-based vessel controller probably will not be the same as those of the ship’s master.¹⁰⁵ Also, when thinking about the different duties in other conventions, it might not be the best solution to assimilate the shore-based ship controller with the ship’s master, seen the completely different working environment and circumstances.

Paragraph 5 of art. 94 UNCLOS also mentions that the flag state taking certain measures, is required to conform to generally accepted international regulations, procedures and practices and to take any steps which may be necessary to secure their observance.¹⁰⁶ By referring to the “generally accepted international regulations, procedures and practices”, UNCLOS points at the whole set of continuously changing international rules, to avoid that these requirements

¹⁰⁴ Art. 94 (4), c UNCLOS

¹⁰⁵ E. VAN HOOYDONK, “The law of unmanned merchant shipping”, *The Journal of International Maritime Law* 2014, (403) 410.

¹⁰⁶ Art. 94 (5) UNCLOS

would form an obstacle when ships or flag states need to comply with new legislation.¹⁰⁷ New conventions could provide some clarity, and flag states would then be able to adapt some new requirements for unmanned shipping.

4.2.2 Genuine link

Ships, including unmanned vessels, are required to have nationality. Ships will have the nationality and will fly the flag of the state in which they are registered. UNCLOS requires that there exists a genuine link between the flag state and the ship.¹⁰⁸ The requirement of a genuine link was installed to avoid that ship-owners would register their vessel in any state they wanted to, and especially in the so-called flags of convenience states. However, the concept of a genuine link never was defined, so the enforcement of the genuine link between ship and its flag states becomes a difficult matter. As a consequence, individual states can sovereignly decide whether the requirement of a genuine link is satisfied or not.¹⁰⁹

To give an idea, what can be interpreted as a genuine link, we can look at the UN Registration Convention¹¹⁰, developed by the UN Conference on Trade and Development (UNCTAD). Despite the fact that the UN Registration Convention never came into force, it gives a clear view of what a genuine link is. The key elements to constitute a genuine link between ship and a flag state are: the ownership of the vessel, the nationality of the crew and the management of the ship.¹¹¹ Nevertheless, ITLOS generally accepts the formal registration of a ship as sufficient to establish the genuine link with a state.¹¹²

Now, with unmanned vessels, the question arises how to establish this genuine link with a state, if the ship doesn't have a crew on board the ship. Prof. E. Van Hooydonk even puts forth that

¹⁰⁷ AAWA, *Remote and Autonomous Ships: The next steps*, Rolls-Royce plc, London, 2016, 38.

¹⁰⁸ Art. 91.1 UNCLOS.

¹⁰⁹ A.J. MARCOPOULOS, "Flags of Terror: An Argument for Rethinking Maritime Security Policy Regarding Flags of Convenience", *Tulane Maritime Law Journal* 2007, (278) 282-283.

¹¹⁰ UN Convention on Conditions for Registration of Ships, 1986 (hereafter: UN Registration Convention).

¹¹¹ Art. 7-9 UN Registration Convention.

¹¹² M. GAVOUNELI, "From Uniformity to Fragmentation? The ability of the UN Convention on the Law of the Sea to accommodate new uses and challenges", in A. STRATI, M. GAVOUNELI and N. SKOURTOS, *Unresolved issues and new challenges to the law of the sea*, Leiden, Koninklijke Brill, 2006, 208-209.

it may be pointless to force unmanned shipping into the concept of nationality of ships, and questions whether the old doctrine, which assumes that ships are part of the territory of the flag state, is still relevant today.¹¹³

Art. 9 of the UN Registration Convention speaks of the ‘manning of ships’, which refers to a crew on board. A possible answer is to establish the genuine link between a state and unmanned vessels, solely on the ownership and the management of the ship. For autonomous ships, without any crew involved, this would be the only possible option. For remote-controlled ships, this could lead to situations where the vessel is monitored and operated from a SCC, located in a low-cost country with poor labour conditions, far away from the flag state. Then the question rises if these operators can be seen as the crew, for the sake of establishing a genuine link. Eventually, this leads to one of the main issues related to unmanned vessels, namely; will the persons operating and controlling the ship ashore be assimilated with a traditional ship crew? This will be discussed further on in this paper.

4.2.3 Time for a constitutional reform?

No matter how comprehensive it was at the time of its conclusion, the constitution of the oceans did not foresee the coming of unmanned shipping. It was impossible to predict this fast technological evolution. Next to the issues mentioned above, there are still some other unresolved details with regard to the operations of unmanned ships and the duties of unmanned ships.

For instance, how will flag states ensure that the unmanned ships will carry the required on board certificates?¹¹⁴ What will happen to the duty that a flag state must require the master to render assistance to persons and other ships in danger, when there is no master on board of the ship¹¹⁵? And how can the right of visit¹¹⁶ and the right of hot pursuit¹¹⁷ be exercised when there is nobody on board of the ship? Looking at all these unanswered questions, Prof. E. VAN

¹¹³ E. VAN HOOYDONK, “The law of unmanned merchant shipping”, *The Journal of International Maritime Law* 2014, (403) 410.

¹¹⁴ Art. 217.3 UNCLOS.

¹¹⁵ Art. 98.1 UNCLOS.

¹¹⁶ Art. 110 UNCLOS.

¹¹⁷ Art. 111 UNCLOS.

HOOYDONK thinks with the coming of unmanned merchant shipping, it would be a good time to modernize the UNCLOS.¹¹⁸

Indeed, 35 years after the adoption of the UNCLOS, it can be said that the convention is starting to grow old, due to the fact that a number of things have changed since the preparation of the convention. But, it's important to understand that UNCLOS is a framework convention, as most provisions can only be carried out through the adoption of other treaties, such as the IMO treaties. UNCLOS allows implementing agreements, complementary provisions and regional rules to modify or suspend its provisions, on the condition that such agreements won't derogate from a provision, that would be incompatible with the effective execution of the object and purpose of UNCLOS, and that those agreements do not affect the basic principles of UNCLOS.¹¹⁹

History has already shown that the law of the sea can be modified and adapted to environmental and technological evolutions, not only through formal instruments, but also via state practice and actions of international organisations, such as IMO, based on the framework of UNCLOS. In this way, numerous activities related to the law of the sea have been regularized. This shows that it's not necessarily UNCLOS that needs to be flexible, but it's in the nature of the law of the sea to be developed and expanded by formal as well as informal sources.¹²⁰

Probably this will also be the case with the breakthrough of unmanned vessels. Whether it will be through a comprehensive IMO treaty or through a flexible interpretation of the UNCLOS provisions, in respect of the letter and spirit of the Convention, the Constitution of the oceans will maintain its important value throughout the challenges of the future.¹²¹ In any case, it should be clear, that consensus through negotiation is the most effective method to secure new changes

¹¹⁸ E. VAN HOOYDONK, "The law of unmanned merchant shipping", *The Journal of International Maritime Law* 2014, (403) 410.

¹¹⁹ Art. 311.3 UNCLOS

¹²⁰ D.R. ROTHWELL and T. STEPHENS, *The International Law of the Sea*, Oxford, Hart Publishing, 2010, 28.

¹²¹ M. GAVOUNELI, "From Uniformity to Fragmentation? The ability of the UN Convention on the Law of the Sea to accommodate new uses and challenges", in A. STRATI, M. GAVOUNELI and N. SKOURTOS, *Unresolved issues and new challenges to the law of the sea*, Leiden, Koninklijke Brill, 2006, 234.

and additions to the law of the sea.¹²² So, in my opinion, the way to handle the challenges related to unmanned shipping, should also be through a negotiated multilateral agreement.

¹²² D. FREESTONE, R. BARNES and D. ONG, *The Law of The Sea: Progress and Prospects*, New York, Oxford University Press, 2006, 61-62.

4.3 Crewing of a ship vs. unmanned ships

“It is not the ship so much as the skilful sailing that assures the prosperous voyage”.

G. William Curtis

Traditionally, seafarers have obtained and enjoyed multiple rights and benefits, that were unique to their profession. And until today, seafarers have enjoyed a protected status, because they are subject to the perils of the sea, and their job is inherent to the global trade. If there are no sailors, the ship can't sail out, so there is no trade, ergo no profit. As stipulated in the quote above, it were the skilled sailors that successfully completed a maritime journey. But with remote-controlled shipping, the importance of their role could be reduced significantly, and with autonomous shipping, even more so.

In this chapter, we will first look at the differences between the traditional seamen and the ship operators in a shore-based control centre. So, because there are no persons involved in the operation of autonomous ships, this part will only handle the case of remote-controlled vessels. Secondly, we will analyse the different tasks and duties of seafarers and the ship's master, and how these tasks should be taken care off in unmanned vessels. Then we will examine the different crew related duties in multiple conventions related to the ship's crew, and how to reconcile them with unmanned vessels.

4.3.1 The contrast between offshore and shore-based workers

Due to the type of their work and lifestyle on board the ship, seafarers differ greatly from land-based workers. The amount of intrinsic hazards linked to working as a seafarer are -still today- much higher than shore-based jobs. One of the main aspects to the seafarer's profession is the fact that all their duties and 'free time' must be executed on board the ship. A seafarer is working, sleeping, living and socializing on the ship, in a multinational crew with unknown people from different cultures and nationalities. In addition, seafarers need to travel through multiple seas, different time zones, changing climates and contrasting weather conditions. The

everyday life of a seafarer takes place in a lonely and dangerous environment, with several disturbing factors such as vibrations, sea motion and noises...¹²³

It is clear that the operators of remote-controlled vessels will work in luxury conditions, compared to those of seafarers. But then the question raises, if a ship is controlled and operated remotely by people working in ashore, to what extent can these people be assimilated with seafarers?

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW)¹²⁴¹²⁵ defines a seafarer as a “*person who is employed, or who seeks employment, as a master, officer or rating on board a ship*”.¹²⁶ The Maritime Labour Convention 2006¹²⁷ (MLC) defines the seafarer in a similar way as “*any person who is employed or engaged or works in any capacity on board a ship to which this convention applies*”¹²⁸. In the International Convention for the Safety of Life at Sea 1974 (SOLAS)¹²⁹, the crew of the ship is defined, as opposed to passengers, as “*the master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship*”.¹³⁰

In the US, there was some confusion of what exactly must be understood under the term ‘seaman’ for the interpretation of remedies of the US Jones Act.¹³¹ In the 1991, the US Supreme Court defined the status of a seaman in the case of *McDermott Intern., Inc v. Wilander*¹³². According to the US Supreme Court, a seaman first of all “*must contribute to the function of the vessel or to the accomplishment of its mission*” and secondly a seaman “*must have a*

¹²³ R. BLANPAIN and D. N. DIMITROVA, *Seafarers’ Rights in the Globalized Maritime Industry*, in *Bulletin of Comparative Labour Relations*, Alphen aan den Rijn, Kluwer Law International, 2010, 27.

¹²⁴ International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, London, 7 July 1978 (hereafter: STCW).

¹²⁵ *Infra* 47.

¹²⁶ Art. III STCW.

¹²⁷ Maritime Labour Convention, Geneva, 23 February 2006 (hereafter: MLC).

¹²⁸ Art. II.1 MLC

¹²⁹ International Convention for the Safety of Life at Sea, London, 1 November 1974 (hereafter: SOLAS).

¹³⁰ Art. II.2 (e) SOLAS.

¹³¹ M. CHWEDCZUK, “Analysis of the legal status of unmanned commercial vessels in U.S. admiralty and maritime law”, *Journal of Maritime Law and Commerce* 2016, 47, (1) 5.

¹³² United States Supreme Court, *McDermott Intern., Inc v. Wilander*, 498 U.S. 337, 111 S. Ct. 807, 112 L. Ed. 2d 866, 1991 AMC 913 (1991).

connection to a vessel in navigation or to an identifiable group of such vessels) that is substantial in terms of both its duration and its nature”.

Only the last description of a seaman could fit the status of the operators in the SCC. Because they are operating the remote-controlled vessel, they namely would contribute to the function of the vessel, and they are definitely in connection with a vessel in navigation. Even so, it is highly doubtful that the judges of the US Supreme court had unmanned vessels in mind when defining the criteria for a seaman. However, the land-based controllers of the vessel would not fit into the definitions of the more relevant conventions such as MLC, STCW, SOLAS, as each of them stipulates the requirement that seafarers are working on board a ship. It should be clear that the work of land-based vessel operators contributes to the navigation of the vessel, similar to the tasks of seafarers, but by carrying out this job on land in regular shifts, the circumstances are still very dissimilar.

Clearly, it would be difficult to force the operators of the remote-controlled vessel into these definitions. But aside of the definitions, it is doubtful whether it would be justified to apply the same policy and same regime as seafarers to the shore-based ship operators. Especially, when considering the fact that seafarers enjoy a protective status, to take away the reluctance to work as seafarer due to the working circumstances.

The status of seafarers is based on some specific elements, inherent to their job. They are working irregular hours in an international environment, they need to be physically fit, they are facing safety risks, sickness, changing climates, perils of the sea and intensive labour with strict deadlines. Above all this, the seafarer is at work for long periods, and has to be months away from home, which puts pressure on his private and social life.¹³³ Shore-based operators on the other hand do not have to deal with any of these challenging elements. It is plausible that the job of a ship operator, is performed in three shifts of eight hours in an office building. In that case, it would be unjust to give these shore-based ship operators the same status as seafarers, because they do not face the factors that justify the special status of seafarers.¹³⁴

¹³³ E. VAN HOOYDONK, “The law of unmanned merchant shipping”, *The Journal of International Maritime Law* 2014, (403) 413.

¹³⁴ M. CHWEDCZUK, “Analysis of the legal status of unmanned commercial vessels in U.S. admiralty and maritime law”, *Journal of Maritime Law and Commerce* 2016, 47, (1) 7.

Still the core task of seafarers, safely completing the maritime journey within time, will be basically the same as the operators of a remote-controlled vessel. Both jobs contribute to the function of the vessel and the accomplishment of its mission.¹³⁵ The vessel operator, although not on board the ship, still has the task to guide the expensive vessel together with the cargo it is carrying to its destination, and avoid accidents and collisions. With this task comes a high responsibility, and that is why shore-based operators also need to possess certain qualities as well as a good seaman, such as the competences to make good judgements and communicating well and being capable of keeping a cool head in emergency situations. And next to all the nautical knowledge required, the shore-based vessel operator will also need to have IT skills to some extent.

In essential, the issue comes down to this. On the one hand, the remote operators are managing the vessel in a SCC, which most likely will be an environment where IT and clerical work is normally performed, such as an office. It is even highly plausible that these remote operators will never step on to the vessel. On the other hand, these remote operators are performing the same task as traditional seafarers, which is navigating the vessel safely to its destination.¹³⁶

So, they have the same duties which could be an argument to apply the same regime. However, these remote operators are not facing the perils of the sea and other private and social challenges, which is the main reason why seafarers enjoy a special regime in maritime law. Therefore, I think the best solution would be to view the remote operators as regular employees with certain capabilities, and to apply the maritime law only to the traditional seafarers, working at sea.

4.3.2 Further degradation of the Ship's Master?

Exactly like when the soul has left a body, and the person is nothing but a corpse, a ship is no more than a wreck, when the captain has left the ship.

(Petit, F., *Beginselen van zeevaartrecht*, Brussel, De Toekomst, s.d., 47)

¹³⁵ United States Supreme Court, *McDermott Intern., Inc v. Wilander*, 498 U.S. 337, 111 S. Ct. 807, 112 L. Ed. 2d 866, 1991 AMC 913 (1991).

¹³⁶ M. CHWEDCZUK, "Analysis of the legal status of unmanned commercial vessels in U.S. admiralty and maritime law", *Journal of Maritime Law and Commerce* 2016, 47, (1) 7.

As the captain is in command of the entire vessel, responsible for the navigation, the crew and the cargo, the ship's master plays an essential role in the global trade, which has boomed the past 70 years.¹³⁷ Once there was a time, where the ship's captain was rightfully called the Master under God, because of his extensive scope of competencies. He is steering the vessel and commanding the crew. It is the ship's master who has the final decision right with regard to the safety of the vessel and the crew. The captain of the ship also has the competence of representing the ship's owner, acting for and on behalf of the owner, within the legal boundaries. In this capacity, the ship's master can hire seafarers and dockworkers, acquiring stores, concluding towing agreements, order repairs, supplies and even concluding contracts of carriage.¹³⁸

Today, the ship's master is no longer a divine figure. The master is bound by his employment contract and working under commercial rules with commercial pressure. Nevertheless, the master remains a sort of civil monarch on the high seas with regard to the ship and the crew. He still has the powers to perform several public tasks as commander, disciplinary judge, police officer, notary, registrar, etc.

Yet, due to new technologies, which led to better means of communication, automation and data exchange, the autonomy of the ship's master in his nautical, operational and technical tasks is further decreasing. His role in the loading and unloading of cargo has been reduced significantly, and his responsibility with ship's documents has diminished.¹³⁹ And then the unmanned vessel would come, which no longer needs a captain, and the Master under God would become a part of maritime history.

As a consequence of unmanned vessels, all the rules with respect to the powers and duties of the ship's master probably will become obsolete. There will be no longer a person on board who is in command of the ship, who will need to act for and on behalf of the owner, who will represent the public authority and who is in charge for the performance of the seafarers. Also, the rules regarding the liability of the ship's master will probably cease to have any object.

¹³⁷ J. A.C. CARTNER, R.P. FISKE, T.L. LEITER, *The international law of the shipmaster*, London, Informa, 2009, 3-6.

¹³⁸ E. SOMERS, *Belgisch Zeerecht*, Larcier Thema Wetboeken, Larcier, Brussel, 2014, 48.

¹³⁹ E. VAN HOOYDONK, "The law of unmanned merchant shipping", *The Journal of International Maritime Law*, 2014, 412.

Unless if it would be convenient to transfer the status of the ship's master, mutatis mutandis to the manager of the SCC.¹⁴⁰ This will be analysed here.

First of all, the same conclusion with regard to the seafarers, can be applied to the ship's master. The manager of the SCC will also work ashore, and therefore is not subject to all the challenges of working and living at sea for a long period.

The ship's master has powers of public authority, as being the commander, police officer, notary, disciplinary judge, public servant and criminal investigating magistrate. The ship's master can exercise these competences only in emergency situations and within strict limitations, because he is the one that is responsible for maintaining the order on the ship at sea. When the ship arrives in port, these competences almost disappear.¹⁴¹ The purpose of these competences completely falls away when the captain would work ashore. Even if the SCC manager is the one with the highest command, there is no reason why he would have powers of the public authority, and in this regard, he should not be assimilated with the ship's master.

The ship's master also has duties of private law; firstly, he must navigate the ship and command the crew and has a final decision power when it comes to the safety of the vessel. This power comes with several duties and linked liabilities in case of non-compliance, which will be discussed further on. These powers could in principle be assigned to the manager of the SCC, without any conflicting issues.

Secondly the ship's master has a mandate to represent the shipowner, which is limited by law. Over the past years, the extent of this mandate has been reduced and some competences of the captain even became useless. When operating a remote-controlled vessel from ashore, the scope of acting as a mandate for his employer, can also be reduced significantly. The new communication technologies enable the shipowner to conclude certain contracts himself or he can directly order certain tasks with the manager of the SCC.

So, it might not be the best choice to give the manager of the SCC the same extensive mandate as the ship's master. In order to be able to handle urgent situations, a mandate could be foreseen

¹⁴⁰ In this thesis, the SCC manager is regarded as the person with the highest function and authority level, in the SCC.

¹⁴¹ E. SOMERS, *Belgisch Zeerecht*, Larquier Thema Wetboeken, Larquier, Brussel, 2014, 42-47.

in the contract (of employment) between the shipowner and the SCC (and its manager). This mandate could then be limited to emergency situations and urgent situations when he could not contact the shipowner, like proposed in the new Belgian Maritime Code.¹⁴²

The ship's master also has some competences as a representative of the cargo owners. For instance, when the consignee refuses to receive the delivery of the cargo, he can ask the court to authorize him to sell the goods.¹⁴³ When there is no captain on board, and the consignee refuses to accept the cargo, the question arises who should take the initiative to ask the court to sell the goods. Is it the manager of the SCC who should take care of this? Most likely, he will not be in the same location as the ship, the cargo and consignee and has no real connection with the handling of the cargo. A local agent of the carrier or consignor would be in a better position to take over this responsibility.

4.3.2.1 Liability of the master

In this section, I will talk about the liability of the master, in the light of the Belgian maritime law. In particular, the duties of the master, linked to possible liability, will be discussed and how to cope with them in case of unmanned vessels.

The criminal and disciplinary liability of the ship's master is laid down in the Disciplinary and Criminal Code for merchant shipping and fishery.¹⁴⁴ This Disciplinary and Criminal Code makes two assumptions for its application. First of all, it makes the assumption that there is a complete human community on board of the merchant ship and that this community can exist of seafarers and passengers. Secondly, it assumes that the captain is the leader of this community. The law gives him the required competencies to carry out this role.¹⁴⁵ However, none of these assumptions are compatible with unmanned ships, so the Disciplinary and Criminal Code should not be applicable on unmanned vessels. Nevertheless, the question could

¹⁴² E. VAN HOOYDONK, *Vijfde blauwboek over de herziening van het Belgisch scheepvaartrecht: Schepelingen*, Antwerpen, Commissie Maritiem Recht, 2012, 160-163.

¹⁴³ Art. 123 Maritime Code.

¹⁴⁴ Wet 5 juni 1982 houdende herziening van het Tucht- en Strafwetboek voor de koopvaardij en de zeevisscherij, *BS* 26 juli 1928.

¹⁴⁵ H. LIBERT, "In de exploitatie van het schip aan boord actieve personen en hun aansprakelijkheid", in I. DE WEERDT, *Grondbeginselen van het Belgisch privaatrechtelijk zeerecht*, Antwerpen, ETL, 1998, 177-178.

raise whether it would be a good idea to assign some of these duties and liabilities to the manager of the SCC.

One of the captain's duties which raises questions when thinking about unmanned vessels is the duty of art. 64 M.C. Art. 64 M.C stipulates that the captain must be personally present on the bridge of the ship when entering or leaving ports and rivers. Breaching this duty will lead to the criminal¹⁴⁶ and civil liability¹⁴⁷ of the captain. Unmanned vessels will probably never have anybody on board, unless in exceptional circumstances. And, because the manager of the SCC presumably will not be assimilated to the master of the ship, this duty and the connected sanctions will become obsolete.

Art. 74 M.C. requires that the captain on duty for a journey must complete the current journey, with the penalty of compensating all costs and damages to the owners and carriers. This duty can eventually be transferred to the SCC, because the cargo owners and carriers still have a high interest in the safe arrival on time and for this, they are dependent on the performance of the SCC. Obviously, when the SCC is responsible for operating the vessel, they should stay responsible until the remote-controlled vessel has reached the port of destination. Therefore, this duty could be implemented in a contract with the SCC, which could give rise to the civil liability. In order to sanction this criminally, a specific law should be ratified for the criminal liability of the SCC (manager).

Art. 77 M.C. states that the captain of the ship cannot abandon the ship before the passengers and the crew have left the ship, because he is the leader of the ship and must command the crew on how to evacuate the ship. In case of unmanned ships, there will be nobody on the ship in the first place, so this rule will have no object anymore. Most likely, this article will also become obsolete with regard to the unmanned vessels.

Another question that arises is what will happen with to the obligation of helping persons and vessels in distress at sea and the linked liability. Art. 62 and 63 of the Criminal and Disciplinary Code sanctions the lack of this duty with imprisonment of one month to two years, and a fine of € 500 to € 5.000. When the unmanned vessel sails closely to a (manned) vessel in distress,

¹⁴⁶ Art. 59 Act 5 June 1928 houdende herziening van het Tucht- en Strafwetboek voor de Koopvaardij en Zeevisserij, *BS* 26 July 1928.

¹⁴⁷ Art. 65 M.C.

there is no person on the unmanned vessel who can help the vessel, crew and passengers in distress. Still, it would be unthinkable that an unmanned vessel could just sail past the vessel and persons in distress. A specific convention / regulation should be adopted in order to specify the concrete tasks that the SCC (manager) should carry out when approaching a (manned) vessel in distress.

4.3.2.2 Conclusion

It is no surprise that the maritime law, based on the old French legislation, such as the “Ordonnance de la Marine” (1681) and the “Code de Commerce” (1807), has not foreseen the coming of unmanned shipping. The figure of the ship’s master cannot be assimilated to the person of manager of the SCC, due to the severe differences in working conditions. The manager in the SCC, is no longer the leader of a human community on board of a ship, so it is unnecessary to give him the same broad powers as the ship’s master. There is no reason why the SCC manager should have the same powers of a public authority. As for the competences of private law, and in particular the mandate for representing the shipowner, it might be a good solution to assign some mandate power for handling in urgent and emergency situations, for and on behalf of the shipowner.

Considering the facts that the SCC manager cannot be assimilated to the ship’s master, and that the Disciplinary and Criminal Code was not set up with the idea of unmanned shipping in mind, the rules governing the liability of the ship’s captain cannot be applied *mutatis mutandis* to the SCC manager. But, when taking into account the large responsibility of the job (navigating an expensive vessel with a huge amount of valuable cargo safely to its destination), the SCC manager should be held liable in some cases, such as gross negligence and wilful misconduct. A new regulation should be put in place to make the SCC manager civil or criminally liable in these cases.

4.3.3 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers¹⁴⁸ (hereafter: STCW) was adopted in 1978. The purpose of the STCW convention was to promote the safety of life and property at sea and to protect the marine environment by establishing an international agreement on the standards, certification and watchkeeping for seafarers.¹⁴⁹ The STCW Convention applies to all seafarers *on board* seagoing vessels, except for the seafarers working on military ships, state-owned ships and non-commercial governmental ships.¹⁵⁰ So, strictly speaking the persons working at the SCC would not be subject to the certifications of the STCW Convention, because they are not on board.

Nevertheless, it is self-evident that the persons operating the vessel from ashore should have certain qualifications and competences. Therefore, a corresponding training regime should be developed to train the persons who would be operating the unmanned ships remotely. Art. IX of the STCW convention has granted the national governments of the contracting possibility.¹⁵¹

The article stipulates:

“The Convention shall not prevent a national government from retaining or adopting other educational and training arrangements, including those involving sea-going service and shipboard organization especially adapted to technical developments and to special types of ships and trades, provided that the level of sea-going service, knowledge and efficiency as regards navigational and technical handling of ship and cargo ensures a degree of safety at sea and has a preventive effect as regards pollution at least equivalent to the requirements of the Convention”. (own underlining)¹⁵²

So, national governments have the possibility to adopt a specialized training regime for unmanned shipping (which can be seen as a technical development and a special type of ship), including an arrangement for sea-going service, as long as there is a certain degree of safety at

¹⁴⁸ Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 7 July 1978 London, as amended in 1995 and in 2010.

¹⁴⁹ X, *International convention on Standards of Training, Certification and Watchkeeping for Seafarers*, 1978, <http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx> (consulted 3 April 2017).

¹⁵⁰ Art. III STCW Convention.

¹⁵¹ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 47.

¹⁵² Art. IX (1) STCW Convention.

sea guaranteed by sufficient knowledge and efficiency on the nautical and technical handling of the ship and its cargo. This degree of safety must be similar to the requirements of the STCW convention.

Yet, when every member state of the STCW convention, would make its own national arrangement, there will always be some slight differences, which could have a detrimental effect on the international shipping business. For instance, some countries (flags of convenience) could impose less strict safety requirements and certificates than other countries with regard to the SCC and its operators. Shipping lines could be tempted to install their remote controlling operators in these countries, because of the lower costs, which could bring down the safety of unmanned vessels. This could eventually raise questions whether unmanned shipping is still as safe as manned vessels.

In case of unmanned vessels, the safety standard should be held high at all time. Maybe even higher than traditional vessels, because of the scepticism that still exists around the concept of autonomous systems. And due to the global character of merchant shipping one uniform regime should come into place. IMO probably is in the best position to work out a training regime for unmanned vessel operators. So far, all we know is that IMO has organized a working group on the regulation of unmanned vessels and is expected to release some details within 2 to 4 years.¹⁵³ Probably, another 5 years will be needed before a regulation will come into force.

Considering the specific skills and qualifications of the ship operators in the SCC, these persons should possess a combination of maritime and IT – Technologic skills in order to control the unmanned vessels with complete knowledge of the operation. The concrete requirements of these qualifications should be regulated in a special arrangement. Meanwhile, it would be a good interim solution to apply the current requirements of the STCW convention and other national requirements on the Shore Control operators analogically, as if they would be working on board the ship. When there is more clarity about the exact training required for operating the unmanned ships from ashore, some provisions should probably be amended in order to comply with the new requirements for operating remote-controlled vessels.¹⁵⁴

¹⁵³ Personal correspondence at IMO, London, 15 November 2017

¹⁵⁴ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 48.

One of the main issues to implement the STCW on unmanned vessels, is the watchkeeping requirement. The STCW code stipulates that the national governments must bring the requirements, principles and guidance of the STCW code to the attention of companies, ship's masters, chief engineer officers and all other watchkeeping personnel, in order to guarantee safe continuous watches according to the circumstances and conditions on all seagoing ships.¹⁵⁵ This includes that *“the officers in charge of the navigational watch are responsible for navigating the ship safely during their periods of duty, when they shall be physically present on the navigating bridge or in a directly associated location such as the chartroom or bridge control room at all times”*, and that the *“operators in charge of an engineering watch shall be immediately available and on call to attend the machinery spaces and shall be physically present in the machinery space during their periods of responsibility”*.¹⁵⁶

According to MUNIN, it is evident that the personnel in the SCC will take over the tasks of the master, the chief engineer and the company.¹⁵⁷ In operating unmanned vessels however, there will be no physical presence on board the ship, neither on the bridge, nor in the machinery space. In this regard, it will be difficult to apply these watchkeeping requirements on unmanned ships. Therefore, AAWA also proposes to amend these instruments to enable commercial ships to operate without any crew or with reduced watch arrangements on board.

Unmanned vessels will be equipped with many advanced sensors and radar systems. These technologies will be able to make an exact assessment of data related to the visibility of the ship. This data will enable the operators ashore to detect vessels and other objects in the proximity of the unmanned vessel. Guided by this data, the SCC must take the appropriate measures to avoid collisions and to ensure the safety of the journey. In case of limited and restricted visibility for instance, it will be the responsibility of the SCC to take the necessary measures to guarantee that the unmanned vessel continues at a safe speed, adjusted to the circumstances and conditions of the weather and visibility.¹⁵⁸ In these more hazardous

¹⁵⁵ Regulation VIII/2 (1) Watchkeeping arrangements and principles to be observed, STCW Convention.

¹⁵⁶ Regulation VIII/2 (2) Watchkeeping arrangements and principles to be observed, STCW Convention.

¹⁵⁷ F. SAFARI and B. SAGE, *Legal and Liability Analysis for Remote-controlled Vessels*, MUNIN, 2013, 18.

¹⁵⁸ F. SAFARI and B. SAGE, *Legal and Liability Analysis for Remote-controlled Vessels*, MUNIN, 2013, 33.

situations, the operators ashore who are in charge of monitoring the engine room, should get the engines ready for an immediate intervention.¹⁵⁹

Unmanned vessels will also occur in congested waters, even though these waters are an even more dangerous situation. When traditional vessels are sailing in congested waters, the officer in charge of the watch is required to use navigational aid systems. Hence, the personnel in the SCC must also make use of this data in order to make an exact assessment of nearby vessels, ashore facilities and ports.¹⁶⁰

On the other hand, the STCW regulation with regard to resting periods in order to prevent fatigue shall be less problematic to apply on the remote operators of unmanned ships. As mentioned before, these operators will probably work in 8-hour shifts in the SCC. As a consequence, resting periods and fatigue most likely will not be a serious issue anymore. This can decrease human errors in the navigation of unmanned ships and an increase of safety of shipping in general.¹⁶¹

4.3.3.1 Conclusion

The STCW convention has come into life to promote the safety of life and properties at sea, by imposing a uniform regulation on the training, certification and watchkeeping of seafarers. The persons operating a vessel from ashore do not fall under the scope of the STCW convention, because this regulation is designed for the people working on board the ship. Of course, this doesn't mean that any person could be operating the vessel in the SCC.

Clearly, there should come some regulation or adaptation of the existing STCW Convention to deal with the training, certifications and watchkeeping requirements in case of personnel in the SCC operating the remote-controlled vessels. The STCW Convention has provided a possibility to the national governments to work out a special arrangement, adapted to technologic developments and special types of vessels, *in casu* the unmanned vessel, ensuring a similar

¹⁵⁹ Ibid.

¹⁶⁰ Ibid, 34.

¹⁶¹ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 48.

degree of safety. Whereas this would be a good first action, disparate national regulations can have some disturbing effects.

For that reason and due to the international character of merchant shipping, it may be more effective to adopt a specific global regime for the training, education, certifications and watchkeeping requirements, taking into account all the opportunities and challenges of unmanned shipping. Such a regime though, is not expected in the first few years. In the meantime, it may be preferable to apply the current regime of the STCW convention on the personnel in the SCC, in the best possible way.

4.3.4 Maritime labour convention

Seafarers have become an essential part of domestic and international trade. The working conditions of seafarers however, weren't an essential concern for their employers. The labour and living conditions of seafarers were (and some still are) substandard. That is why the International Labour Organization adopted the Maritime Labour Convention¹⁶² (MLC) in 2006, which entered into force in 2013. The purpose of the MLC was to improve the labour conditions for seafarers around the world by establishing human and labour rights for all seafarers.¹⁶³ The MLC addresses a range of topics such as, the minimum requirements to work on a ship, the employment conditions, medical care and accommodation and recreational facilities on board.

The MLC applies to all seafarers.¹⁶⁴ For the application of the MLC, a seafarer is defined in the MLC as “*any person who is employed or engaged or works in any capacity on board a ship to which the MLC applies*”.¹⁶⁵ According to this definition, the personnel operating the vessel in the SCC cannot enjoy the rights and conditions in this convention. However, there might be a loophole which could make the application still possible.¹⁶⁶

In cases of doubt whether certain categories of persons can be regarded as seafarers, the competent authorities of each member state have the ability to resolve this issue, after

¹⁶² Maritime Labour Convention, Geneva, 23 February 2006. (hereafter MLC 2006).

¹⁶³ P.J. BAUER, “Guarantee of Seafarer Rights, or an Impediment to True Reforms?”, *Chicago Journal of International Law* 2008, (643) 643.

¹⁶⁴ Art. II.2 MLC.

¹⁶⁵ Art. II.1 (f) MLC.

¹⁶⁶ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 49.

consulting the relevant shipowners' and seafarers' organizations.¹⁶⁷ This paragraph was inserted in the MLC because of the awareness that there is a large scope of different people working at sea and carrying out several jobs that traditionally weren't part of the seafaring workforce or maritime labour conventions, such as kitchen personnel, sports instructors and entertainers on passenger ships. These employees often are not governed by maritime labour conventions, because they are not involved in the operation of the ship. That is why the MLC has foreseen some national flexibility to qualify these categories of employees as seafarers.¹⁶⁸

But still, then it comes to the discussion whether it is still doubtful if persons operating the vessel from ashore can be qualified as seafarers, when they would never come on board a ship. Especially when considering the fact that the paragraph of art. II.3 MLC has the purpose to qualify those people as seafarer, who work on board the ship, but are not operating the ship. Probably the personnel in the SCC will not be considered as seafarers under the scope of the MLC.

Nevertheless, considering the fact that the provisions of the MLC mainly focus on the living and working conditions on board the ship, a large number of provisions would become irrelevant when they are applied on the remote operators working ashore in an office building. The employment conditions, the working and resting periods, minimum wages, etc. of the shore-based ship operators will most likely be governed by the labour laws, which are applicable to the traditional land-based employees. If required, the existing labour laws can be complemented with special rules to consider the specific characteristics of the tasks of the remote controlling operators.¹⁶⁹

4.3.4.1 Manning levels

Despite the fact that the scope of application on seafarers is open for debate with regard to unmanned vessels, the MLC applies to all ships, engaged in commercial activities, except those that are engaged in fishing or in similar pursuits.¹⁷⁰ The term 'ship' is limited to ships that are

¹⁶⁷ Art. II.3 MLC.

¹⁶⁸ ILO, Preparatory Technical Maritime Conference, *Consolidated Maritime Labour Convention: Commentary to the recommended draft*, Geneva 2004, 7-8, <http://ilo.org/public/english/standards/relm/ilc/ilc94/ptmc/pdf/cmlc-comment.pdf>

¹⁶⁹ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 49.

¹⁷⁰ Art. II.3 MLC.

not only navigating in inland waters, or within sheltered waters or only navigating in port areas.¹⁷¹ So clearly, unmanned (merchant) vessels do fall under the scope of the MLC. It's only their operators ashore that do not fit the scope of the MLC.

One provision that may pose a hindrance to the operation of unmanned vessels is the regulation 2.7 of the MLC related to the ship's manning levels. The regulation requires that all ships have a sufficient number of seafarers employed on board to ensure that ships can operate safely, efficiently and with due regard to security in all conditions. Every ship shall be manned by a crew and particularly the size and qualifications of the crew should be adequate to ensure the safety and security of the ship and its personnel. The competent authorities should comply with the minimum safe manning document.¹⁷²¹⁷³ This provision is mainly introduced due to concerns about seafarer fatigue and on-board security issues.¹⁷⁴

Certainly, fatigue of seafarers will no longer be an issue with unmanned vessels. But the question is whether this will be enough to move this regulation aside. In any case, shipowners will have to prove that the unmanned vessel is designed and constructed in a way where they can navigate safely without anyone on board the vessel. So speaking of manning levels with unmanned vessels may be a bit inconsistent and useless as well.

4.3.4.2 Conclusion

The MLC regulates and improved the working and living conditions of seafarers. According to the definition in the MLC, the shore-based controllers of the vessels strictly cannot be qualified as seafarers. The MLC has provided the national authorities with a possibility to be more flexible in the determination of who is a seafarer and who is not, but this possibility is actually made from the point of view to qualify employees, who are not involved in the operation of the ship, but do work on board the ship, as seafarers.

¹⁷¹ Art. II.1 (i) MLC.

¹⁷² Infra 55.

¹⁷³ Reg. 2.7 MLC.

¹⁷⁴ ILO, Preparatory Technical Maritime Conference, *Consolidated maritime labour Convention: Commentary to the recommended draft*, Geneva 2004, 26, <http://ilo.org/public/english/standards/relm/ilc/ilc94/ptmc/pdf/cmlc-comment.pdf>

So, the MLC probably is not applicable on the shore-based operators of unmanned vessels. This isn't a total catastrophe, as most of the provisions of the MLC focus on the living and employment conditions, specialized for working and living long periods at sea. As a conclusion, the remote operators working ashore, will in the first place be governed by the same labour regulations as the regular land-based employees. Additionally, there may come some new regulation into play, taking into account the specific tasks of operating a vessel from ashore.

Unmanned ships, as opposed to their operators, will be governed by the provisions of MLC. The MLC requires that all vessels shall be operated by a sufficient number of qualified seafarers on board to ensure the safe, efficient and secure operation. However, unmanned vessels will be designed and manufactured in a manner where they can operate safe, efficient and secure, without having any person on board. Hence, this provision will have no valuable effect on unmanned vessels.

4.3.5 SOLAS Convention

The International Convention for the Safety of Life at Sea (SOLAS), 1974¹⁷⁵, is the most important international treaty dealing with maritime safety. The first version was adopted in 1914, as a response to the *Titanic* disaster, losing more than 1.500 lives. Since then there have been four more versions adopted. The present one applicable dates back from 1974, and has been amended several times.

The purpose of SOLAS is to specify the minimum standards for the construction, equipment and operation of vessels to guarantee their safety.¹⁷⁶ Each chapter of SOLAS lays down detailed standards that determine the minimum performance criteria that needs to be met in each area. Twelve chapters of SOLAS have each been dedicated to one area relating to maritime safety, such as: the construction and stability of ships; fire protection; safety of navigation; carriage of dangerous goods; additional safety measures for specific types of ships; etc.

¹⁷⁵ International Convention for the Safety of Life at Sea, London, 1 November 1974, as amended (hereafter SOLAS).

¹⁷⁶X, *International Convention for the Safety of Life at Sea (SOLAS), 1974*, [http://www.imo.org/en/About/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-\(solas\),-1974.aspx](http://www.imo.org/en/About/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas),-1974.aspx) (consulted 5 April 2017).

The flag states of vessels bear the responsibility to comply with these standards by issuing compliance certifications, such as the Safety Construction Certificate, the Safety Equipment Certificate, the Passenger Ship Safety Certificate and so on. Port states then have the authority to inspect these certificates on board of foreign ships. If the conditions on board do not accord with the received certificates, they have the ability to conduct further examinations and take measures.¹⁷⁷

Because this chapter handles the legal challenges related to the crew and manning requirements of ships, this subchapter will concentrate on Chapter V of SOLAS regarding the safety of navigation, with particular attention on the rules that could pose a challenge for unmanned vessel. Other chapters of SOLAS will be discussed further.

4.3.5.1 SOLAS: Chapter V

The fifth chapter of SOLAS covers the navigation safety services that should be provided by the national governments. A number of different subjects are handled, including the maintenance of meteorological services for ships, the ice patrol service, routing of ships and the maintenance of search and rescue services. Some of the regulations of Chapter V will be more difficult to implement through unmanned vessels, for example: the regulation on the manning of ships, the voyage planning, the bridge visibility requirements and the duty to assist vessels in distress.¹⁷⁸

Whereas other chapters are only applicable on vessels with a certain tonnage, or only on merchant vessels or only vessels on an international voyage, Chapter V applies to all ships on all voyages, save warships and ships navigating the Great Lakes of North America.¹⁷⁹

Reg. V/14 is of particular importance to this subchapter. This regulation requires that national authorities must maintain or adopt measures, to ensure that all ships, flying their flag, shall be sufficiently and efficiently manned.¹⁸⁰ This requirement is inserted from the point of view of the safety of life at sea. So, it is the responsibility of the flag state to determine whether a ship

¹⁷⁷ A.J. NORRIS, *Legal Issues Associated with Unmanned Maritime Systems*, U.S. Naval War College, 2013, 50-52.

¹⁷⁸ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 43.

¹⁷⁹ Reg. V/1 SOLAS.

¹⁸⁰ Reg. V/14 (1) SOLAS.

is sufficiently manned or not. When the flag state decides that the number and qualifications of the crew is sufficient for the ship in question, they will issue a safe manning document for the ship.¹⁸¹ Reg. V/14 refers to the Principles of Minimum Safe Manning, as a guideline of criteria, according to which flag states can determine if the manning is adequate.

4.3.5.1.1 Minimum manning requirements

In order to decide if it's rightful to issue a safe manning document or a similar document, the flag state administration can guide themselves with the Principles of Minimum Safe Manning¹⁸². In essential, for unmanned vessels it comes down to the question whether the flag state authorities will issue a safe manning document, when there is no person working on board the ship. And, despite the fact that there isn't anyone on board, will the flag state administration be convinced that an unmanned ship can safely perform all of its operations? Of course, the answer to these questions will depend on to what extent shore-based vessel operators can take over and carry out the tasks of a traditional crew.¹⁸³

First of all, in deciding if a safe manning document can be issued, the flag state should take all relevant factors into account, such as the size and type of ship; the construction and equipment of the ship; the cargo to be carried, etc.¹⁸⁴ But the Guidelines of the Principles of Safe Manning also mention three factors that will be of particular importance in case of unmanned vessels;

- the technical equipment of the ship;
- the level of ship automation;
- and the degree of shoreside support provided to the ship by the company.¹⁸⁵

When the flag state would issue a safe manning document for a safely operating unmanned vessel, it can found its decision mainly on these three factors. Naturally, this can only be issued, if all the underlying principles of safe manning (safe navigation, safely mooring) are satisfied as well. If so, and if the vessel is correctly configured, a flag state could issue a safe manning

¹⁸¹ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 43.

¹⁸² IMO, Resolution A. 1047(27), *Principles of Minimum Safe Manning*, 30 November 2011.

¹⁸³ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 43.

¹⁸⁴ Annex 2, IMO Resolution A. 1047(27), *Principles of Minimum Safe Manning*, 30 November 2011.

¹⁸⁵ Ibid.

document for a vessel, where the minimum manning requirement is actually brought back to zero.¹⁸⁶

Secondly, if a flag state is convinced and certain that the functions of a vessel, which are necessary to navigate safely, can be executed from ashore, there would be no provision in SOLAS or in the Guidelines of Safe Manning that would be directly breached by that decision. And indeed, the land-based ship operators will probably be able to carry out the operational activities as well as the maintenance and service work. On top of that, it might be very well possible that unmanned vessels will be safer than traditional vessels, when more functions are assigned to shore-based operators and advanced systems and equipment come on board the ships.¹⁸⁷

However, shipowners of unmanned vessels will still need to convince flag state authorities that their unmanned vessel can safely operate in all circumstances. The flag state will need to be certain of this, before issuing a safe manning document and allowing them to fly their flag, because of the responsibility that comes with it. Next to that ambiguity, it is also uncertain to what extent we can translate the SOLAS provisions and the Guidelines of Safe Manning to unmanned vessels, because they clearly were not drafted with the future of crewless shipping in mind.¹⁸⁸

So as long as there is no adapted regulation on unmanned vessels, it will come down to the judgment of the flag state authority whether an unmanned ship will be sufficiently “manned”, when there is no one aboard the ship. The Principles of Safe Manning provide some clauses that would allow the flag state to ground their decision when issuing a safe manning document.

As of today, the technology is in an advanced phase, while the modernization of regulations still is somewhat reluctant. And one thing already is clear; when the technology is advanced enough to carry out operational tasks without the assistance of a crew on board, the

¹⁸⁶ P.W. PRITCHETT, “Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology”, *Tulane Maritime Law Journal* 2015, (197) 203.

¹⁸⁷ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 44.

¹⁸⁸ *Ibid.*

requirements of minimum manning will lose their relevance and will become a hindrance to technological innovations.¹⁸⁹

4.3.5.1.2 Other challenges

Some other regulations of SOLAS Chapter V could constitute some minor challenges with the unmanned vessels. The plausible challenges will be discussed briefly in this section. In particular, the issues with the requirements of the bridge visibility, the duty to provide assistance, and the requirements of safe navigation will be handled.

First, the Reg. V/22 poses several requirements with regard to the navigational bridge to ensure the visibility when looking out from the bridge. For instance, view of the sea surface may not be obscured by more than 2 ships' lengths, and the cargo may not cause a blind spot which could obstruct the view on the sea surface.¹⁹⁰ Clearly, these requirements find their existence in the fact that the bridge crew needs a clear overview of what's happening at sea to increase the safety of navigation.

With unmanned vessels, the bridge as we know it today, will probably undergo some changes. Due to the fact that there is no bridge crew anymore, these visibility requirements lose their object. Advanced sensor modules and radars will take over these tasks. But to make sure that these systems can function properly, their sight may not be hindered. Therefore, it may be a good solution to adopt an amendment relating to the visibility of the sensors. Such a regulation should contain provisions about the minimum height of these sensors, and the maximum height of the cargo, to make sure that the sensors will not be hindered.

Secondly, Reg. V/33 stipulates the duties and procedure when distress messages have been issued; "*the master of a ship at sea which is in a position to be able to provide assistance, on receiving a signal from any source that persons are in distress at sea, is bound to proceed with all speed to their assistance, if possible informing them or the search and rescue service that the ship is doing so*".¹⁹¹ When examining this article, one can find several reasons to argue that this provision will not apply on unmanned vessels. There is no master on board and the operator

¹⁸⁹ P.W. PRITCHETT, "Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology", *Tulane Maritime Law Journal* 2015, (197) 204.

¹⁹⁰ Reg. V/22 (1) SOLAS.

¹⁹¹ Reg. V/33 SOLAS.

in the SCC cannot be assimilated to the master. Furthermore, shipowners could also argue that an unmanned vessel is not a “*ship in a position to be able to provide assistance*”, simply because there is no one on board.

Yet, it would lead to unethical situations if a vessel and its crew are in distress, and unmanned vessel would just sail past by. For that reason, it may be a good opportunity to adopt some specific regulation regarding the duties of unmanned vessels and the shore-based operators. At the very least, there should be some compulsory notification to the search and rescue services from the SCC. It could also be a good idea to require that the unmanned vessels are equipped with some safety and rescue material, so they can remotely operate the assistance to persons in distress.

Thirdly, Reg. V/34 stipulates how to navigate safely and how to avoid dangerous situations.¹⁹² This regulation imposes that the master has an exclusive decision right, when it comes to decisions regarding the safety of navigation and the protection of the marine environment. Not the shipowner, nor the charterer or the company can restrict or prevent the master from following his judgment.¹⁹³ As mentioned before, there will be no master involved in the operation of unmanned vessels, so the question is whether this exclusive decision right will still exist? And if so, who is in the best position to make this decision?

The answer will depend on several factors. As the persons operating the ship in the SCC really are in charge of the vessel, and they are supposed to have the most knowledge and experience to assess safety issues, they should also have the power to make the final decisions related to the safety of the ship. Whether the shipowner or charterer or their agents should have some decision power can be doubted, as they may have other priorities than the safety, such as the speed of arrival at the port of destination. Anyhow, the concrete arrangement of this decision power with regard to the safe navigation should also be adjusted to unmanned shipping.

4.3.5.2 Conclusion

While the SOLAS convention handles a large number of subjects with regard to the safety of vessels, Chapter V may be the most relevant for crew regulations. The main concern when

¹⁹² Reg. V/34 SOLAS.

¹⁹³ Reg. V/34 (3) SOLAS.

applying Chapter V of the SOLAS convention to unmanned vessels, will certainly be the minimum manning requirements. According to Reg. V/14, the national authorities should ensure that a ship is safely and sufficiently manned.

As long as there is no specific regime applicable for unmanned vessels, the flag state administration will have to determine if ships can navigate safely without a crew on board. In their assessment, they can focus especially on 3 important factors, provided by the Principles of Minimum Safe Manning, namely: the technical equipment of the ship; the level of ship automation; and the degree of shoreside support provided to the ship. If the flag state administration concludes that the unmanned vessel can navigate safely, they should issue a safe manning document, when the number of crew on board is zero.

Chapter V of the SOLAS convention also creates some other challenges for unmanned vessels, that need to be taken care of. The visibility requirements on the navigational bridge, should be adapted for unmanned ships, taking into account the absence of the crew and the presence of sensor and radar systems. The procedure in case of passing vessels in distress, should be adjusted to unmanned ships, taking into account the capabilities of the personnel ashore. And the execution of the final decision power relating to the safety of navigation should also be readjusted to the situation of unmanned shipping.

4.4 Ship operation

Whereas the previous chapters handled the position of an unmanned vessel in the international law of the sea and the challenges for unmanned ships with regard to the crewing regulations, this chapter will handle the legal issues of unmanned ships relating to the navigational aspects. In particular, this chapter will focus on the International Regulations for Preventing Collisions at Sea and multiple SOLAS chapters.

4.4.1 COLREGs

“Whilst walking along a pavement at peace with world, have you ever had the experience of spying a fellow pedestrian wandering towards you? The other fellow is some way off, but head on and trying in vain to take evasive action. The closer you get, the more course changes you both make, but despite there being very few others around, you still contrive to clash bags or briefcases, or even grind to an embarrassing halt, face-to-face. Now put this scenario in the context of two ships at sea.”¹⁹⁴

As a consequence of the industrial revolution, global trade developed, which caused an increase in the number of ships at sea. In order to safely accommodate the growing marine traffic, maritime powers adopted the first navigation rules in the 19th century. Since then, these rules have been adapted a number of times and have become an essential element in maritime transport and maritime law.¹⁹⁵ The Convention on the International Regulations for Preventing Collisions at Sea, 1972¹⁹⁶ (hereafter: COLREGs), is the primary international instrument handling the prevention of collisions at sea and navigational rules. The COLREGs, also known as The Rules of the Road at sea, are a set of navigational rules, with the purpose of avoiding collisions at sea.

The goal of the COLREGs was to make shipping safer by creating common navigational behavioural patterns and require that all vessels are equipped with similar navigating gear. The

¹⁹⁴G. KING, *Rule of the Road – Explained*, <http://shipofficer.com/so/rule-of-the-road-explained/> (consulted 8 April 2017).

¹⁹⁵ P.W. PRITCHETT, “Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology”, *Tulane Maritime Law Journal* 2015, (197) 206.

¹⁹⁶ Convention on the International Regulations for Preventing Collisions at Sea, London, 20 October 1972 (hereafter COLREGs).

COLREGs are composed of 9 general articles, followed by 38 rules, containing the maritime traffic rules, with 4 annexes containing technical requirements.¹⁹⁷ Different topics are handled such as the visibility requirements, the safe speed, the lights and shapes on vessels, the sound and light signals and the priority and manoeuvring rules for different types of vessels.¹⁹⁸ Next to navigational rules, the COLREG rules also play an important role in allocating liability in case of an accident. So, the COLREGs are a vital convention of maritime law. The question is how unmanned vessels should comply with these rules.

Rule 1(a) stipulates that the COLREGs apply to all vessels on the high seas and in all waters connected therewith, which are navigable by seagoing vessels.¹⁹⁹ And as mentioned earlier, the COLREGs define the word “vessel” as *every description of water craft, including non-displacement craft, Wing-In-Ground craft and seaplanes, used or capable of being used as a means of transportation on water*”.²⁰⁰ The essence of this definition comes down whether a water craft is capable of being used as means of transportation on water. Clearly, an unmanned vessel will also qualify as a vessel according to this broad definition, as it is a water craft used as a means of transportation. Hence, unmanned vessels will be subject to application of the provisions of COLREGs.

The COLREG rules require that the officer in charge of the navigational watch must take early and positive actions which decrease the collision risks, in cases when there is a chance of collision when sailing near other vessels, water crafts or other objects. And Rule 2 expressly stipulates that no vessel, or owner, master or crew in the COLREG rules shall be exonerated from the consequences of any neglect to comply with these rules or of the neglect of precaution, which may be required.²⁰¹ As in the MUNIN project, it is assumed that the manager of the SCC has the responsibility for operating the remote-controlled vessel, and it’s him who must take these actions.²⁰²

¹⁹⁷ L. GIUNTA, *The Enigmatic Juridical Regime of Unmanned Maritime Systems*, Venice, Ca’ Foscari University of Venice, 2015, 4.

¹⁹⁸ X, *Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs)*, <http://www.imo.org/en/About/conventions/listofconventions/pages/colreg.aspx> (consulted 9 April 2017).

¹⁹⁹ Rule 1(a) COLREGs.

²⁰⁰ Rule 3(a) COLREGs.

²⁰¹ Rule 2(a) COLREGs.

²⁰² F. SAFARI and B. SAGE, *Legal and Liability Analysis for Remote-controlled Vessels*, MUNIN, 2013, 21-22.

4.4.1.1 The Lookout

With the ultimate goal to prevent collisions, every vessel, as well as unmanned vessels, shall at all times maintain a proper lookout by sight and hearing, as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the collision risk.²⁰³

This rule, formerly a rule of good seamanship, applies in any condition of visibility. In previous regulations, the duty of a proper lookout mostly referred to the fact that there is always a duty to be reasonably skilful and careful. In the past, several cases have dealt with this rule and have connected it with other rules of good seamanship.²⁰⁴ For instance, courts have ruled that normally, one or more hands should be stationed on the lookout, by day and night.²⁰⁵ Also, a visual lookout should be kept, even when a radar is activated.²⁰⁶ And, when a vessel is equipped with a radar, this should be used as an aid in keeping a proper lookout, as it is one of the “available means”.²⁰⁷

As unmanned vessels are subject to the COLREG rules, unmanned vessels will need to comply with the duty of a proper lookout at all time. With remote-controlled vessels, the personnel in the SCC could have a lookout by all appropriate means available. But looking from the technical perspective, the lookout can basically be an autonomous function, with assistance from the SCC in exceptional circumstances.²⁰⁸ But the question is whether unmanned vessels can comply with this rule in such way. Therefore, we’ll take a look at the purpose and the wording of the lookout rule.

The objective of the lookout rule is to assure that the person who is operating the ship, can be and is aware of all things around him, in order to make calculated decisions.²⁰⁹ He should not only be attentive for large objects in the proximity, such as other vessels, but also for items

²⁰³ Rule 5 COLREGs.

²⁰⁴ R.H.B. STURT, *The Collision Regulations*, London, Lloyd’s of London Press, 1991, 39-40.

²⁰⁵ Ellerman Lines Ltd./Trustees of The Harbour of Dundee, *T.L.R* 1922, 299.

²⁰⁶ *The Anneliese*, *Lloyd’s Rep* 1970, 36.

²⁰⁷ *The Golden Mistral*, *Lloyd’s Rep* 1986, 407.

²⁰⁸ F. SAFARI and B. SAGE, *Legal and Liability Analysis for Remote-controlled Vessels*, MUNIN, 2013, 31.

²⁰⁹ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 46.

adrift in the water.²¹⁰ The person on the lookout assembles all information about the environment surrounding the vessel, and reports this to the person who can evaluate this data and can make the operational decisions.

Now, this is one of the main advantages of unmanned vessels. Unmanned vessels will be equipped with advanced sensors. The new systems, equipped with modern sensors, are designed to ensure that they will detect any object within a range of 5km. Currently, these systems are under development, and use two kinds of sensors. They use electronic sensors to detect objects faraway, of which the positions are considered when the system determines the route. Next to these sensors, other sensors will locate the closer objects, forming a more immediate collision threat, which allows the system to avoid these objects. These systems could even detect and predict locations of moving objects.²¹¹

Furthermore, these autonomous systems will completely eliminate human errors at the lookout, such as fatigue, attention deficit and situations of unawareness. In principle, the available information for making navigational decisions will be far more accurate and reliable than it is with traditional vessels.²¹² In case of remote-controlled vessels, the equipment allows the SCC to have a clear overview of the ships' surroundings, so they are able to take correct actions in time.²¹³ In case of fully autonomous vessels, the data collected at the lookout, will be transferred to a computer on board, which will evaluate this data and will send out the directions to the engines, rudders and other navigational gear.²¹⁴ So, regarding the purpose of the lookout rule, the lookout on unmanned vessels, which is performed by advanced sensors, will even be an improvement in that perspective.

Yet, unmanned vessels should not only comply with the purpose of this rule, they should also comply with the wordings of rule 5 of the COLREGs. Using the terms "proper lookout by sight and hearing", the COLREG rules do not necessarily require a person as a lookout, but rather an organized gathering of information. This means that either who is in charge of the lookout, must

²¹⁰ P.W. PRITCHETT, "Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology", *Tulane Maritime Law Journal* 2015, (197) 205.

²¹¹ Ibid.

²¹² H-C. BURMEISTER, W.C BRUHN, Ø. J. RØDSETH and T. PORATHE, *Can unmanned ships improve navigational safety?*, Paris, Paris Transport Research Arena, 2014, 8.

²¹³ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 46.

²¹⁴ P.W. PRITCHETT, "Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology", *Tulane Maritime Law Journal* 2015, (197) 199.

only ensure that the information regarding the ship's surroundings is detected in time and directly communicated to the vessel operator, so he can make informed decisions.²¹⁵ Also the terms “proper” and “appropriate means” indicate that there is some room for flexibility in organizing the lookout.²¹⁶

The lookout rule stipulates that it should be carried out by “sight and hearing and all available means appropriate”. While not so long ago, the “available means” only was a spyglass, this has radically evolved over time, to tools that have capabilities beyond the human senses. Today modern vessels make use of several other tools for maintaining the lookout, such as; radar, automated radar plotting aids, differential GPS satellite navigation, Automatic Identification Systems (AIS) radio transponders, Vessel traffic services (VTS) and other navigational and piloting instruments.²¹⁷ Unmanned vessels, equipped with autonomous sensor systems would be the next step in the evolution of the lookout.

As a conclusion, it is probably safe to say that the wording of Rule 5 of the COLREGs is broad enough to interpret it in favour of unmanned vessels. This interpretation would allow to replace the human lookout, by different types of cameras, sensors, radar and audio technology. Of course, this interpretation can only be accepted if the incentive of the lookout rule is satisfied, namely to avoid collisions and to prevent marine pollution. As discussed earlier, this would be the case; the sensor technologies are able to detect large and small objects, nearby or from a far distance. As these systems can detect beyond the human capabilities, they will be more accurate and reliable than the current lookout. As a consequence, the lookout carried out by these systems will be safer, because they improve the ability to avoid collisions and prevent marine pollution.

4.4.1.2 Safe Speed

Rule 6 of the COLREGs requires that “*every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and can be stopped within a*

²¹⁵ LLANA and WISNESKEY, *Handbook of the Nautical Rules of the Road*, <http://navruleshandbook.com/Rule5.html> (consulted 10 April 2017).

²¹⁶ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 46.

²¹⁷ LLANA and WISNESKEY, *Handbook of the Nautical Rules of the Road*, <http://navruleshandbook.com/Rule5.html> (consulted 10 April 2017).

*distance appropriate to the prevailing circumstances and conditions.*²¹⁸ In case of unmanned vessels, this obligation will need to be followed by the operators in the SCC in all conditions of visibility, as they are ought to take over the role of the master and the crew. When determining a safe speed, they should take into consideration two categories of factors.

The first group they should take into account, are the factors that needs to be considered by all vessels. These factors are pretty straightforward. For establishing a safe speed, they need to take into account the following:

- The state of visibility;
- The traffic density, including the concentrations of fishing vessels or any other vessels;
- The manoeuvrability of the vessel, with special reference to the stopping distance and the turning ability in the prevailing conditions;
- The presence of background light at night, such as from shore lights or from back scatter of the vessels' own lights;
- The state of the wind, sea and current, and the proximity of navigational hazards;
- And the draft in relation to the available depth of water.²¹⁹

The second group are the factors that must be taken into account by vessels with an operational radar. Vessels making use of an operational radar, will mostly sail at higher speeds in situation of restricted visibility. That is why they need to take additional elements in consideration, when determining a safe speed. As unmanned ships will be highly dependent on radars and sensors, they should also deal with the following factors:

- The characteristics, efficiency and limitations of the radar equipment. The efficiency of the equipment to detect vessels and other objects, is also related to the competence of those observing the radars.²²⁰
- Any constraints imposed by the radar range scale in use. For instance, when applying the radar on a longer range scale, small objects are less likely to be detected, whereas when a short range scale is applied, the radar would not be able to detect objects faraway

²¹⁸ Rule 6 COLREGs.

²¹⁹ Rule 6(a) COLREGs.

²²⁰ A. N. COCKCROFT and J.N.F. LAMEIJER, *A guide to the Collision Avoidance Rules*, Oxford, Elsevier Butterworth-Heinemann, 2004, 30-31.

early.²²¹ However, because unmanned vessels are also equipped with sensors and other systems, this issue will probably be reduced significantly.

- The effect on radar detection of the sea state, weather and other sources of interference;
- The possibility that small vessels, ice and other floating objects may not be detected by a radar at an adequate range;
- The number, location and movement of vessels detected by the radar. When there is a greater number of targets indicated on the radar, it will be more difficult to determine the collision risk and to estimate the effect of certain manoeuvres. However, the more advanced radars are already able to provide navigational information in these circumstances.²²²
- The more exact assessment of the visibility that may be possible when the radar is used to determine the range of vessels or other objects in the vicinity.²²³

The shore-based operators of unmanned vessels should take all these elements into account when determining the speed of the vessel. But some factors will be of less relevance, according to the performance, efficiency, and accuracy of the systems on board the unmanned vessel.

4.4.1.3 The safe navigation

The steering and sailing rules (Part B) of the COLREGs are applied to all vessels. There is no provision that stipulates who should take the decisions regarding the steering and sailing. So in principle, there is no textual obstacle for putting shore-based operators in the SCC in charge of navigating remote-controlled vessels.²²⁴ In the case of remote-controlled vessels, the SCC has the obligation and responsibility for operating the vessel and must take all preventive actions to avoid collisions. Hereby they should make optimal use of the information delivered by the radar and sensor systems.²²⁵

²²¹ Ibid, 31.

²²² Ibid, 34.

²²³ Rule 6(b) COLREGs.

²²⁴ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 46.

²²⁵ F. SAFARI and B. SAGE, *Legal and Liability Analysis for Remote-controlled Vessels*, MUNIN, 201323.

However, when the level of automation increases to fully autonomous vessels, it may become more difficult to implement the navigation requirements of the COLREGs, because there is no operator in charge of the decision making.

When we look at the compliance of fully autonomous vessels with the navigational rules from a technical point of view, this would still be feasible. In the near future, algorithms will be created and tested so that autonomous vessels can precisely comply with the steering and sailing rules, and autonomous vessels will even be able to operate in unpredictable actions.²²⁶

Currently, various models are being developed, with diverse results. Some models seem to be capable to comply with the navigational rules when encountering objects, but a recalculation of the route takes too long, which could be impractical and dangerous in real-life situations.²²⁷ Other models haven't proven to be successful in real-life when encountering single and static objects, but seem to be lacking in performance when they encounter multiple dynamic objects.²²⁸ The research and development on these algorithms is expanding heavily, so the future will bring more answers on this and it probably won't take too long anymore.

Another issue that arises when it comes to fully autonomous vessels and the compliance with COLREGs, is that not all of the COLREG rules are clearly stipulated. For instance, Rule 2 (b) stipulates: "*in construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger*". So, when a vessel comes in an exceptional situation with an immediate danger, the vessel can be expected to depart from the COLREG rules.²²⁹ As all other COLREG rules, this provision assumes that there is an experienced master and crew on board the ship, who are able to take cautious decision in such circumstances.

²²⁶ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 46.

²²⁷ P.W. PRITCHETT, "Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology", *Tulane Maritime Law Journal* 2015, (197) 207.

²²⁸ Ibid.

²²⁹ A. N. COCKCROFT and J.N.F. LAMEIJER, *A guide to the Collision Avoidance Rules*, Oxford, Elsevier Butterworth-Heinemann, 2004, 8.

This is not the case with autonomous vessels. Rule 2(b) implicitly refers to a rule of good seamanship, which will be hard to implement into an autonomous navigation programme.²³⁰ In what way a computer will react in dangerous situations, cannot be predicted, which raises concerns on what its reaction will be. Aside from the fact that autonomous vessels would not comply with the COLREGs on this part, they are definitely unsafe when we can't predict how they would act in dangerous situations. Probably, future research will go deeper into this issue in order to make sure that autonomous vessels can act appropriately in such circumstances.

4.4.1.4 Conclusion

The Collision Regulations will be applicable to unmanned vessels and they will bring some challenges with them. As for the lookout rule, the traditional human lookout will be replaced by advanced sensor and radar systems. These systems satisfy the phrasing and the purpose of the lookout rule and will even be able to perform the lookout more reliable and accurate, hence in a safer way.

The obligation that a vessel must proceed at a safe speed must also be followed by ship operators in the SCC. In determining a safe speed, all vessels are required to take several factors into consideration. However, since unmanned vessels will be highly dependent on radars and sensors in order to operate, the shore-based operators must especially take the second group of factors into account, which are mandatory for vessels using an operational radar.

With regard to the safe navigation, the distinction between remote-controlled and fully autonomous vessels is relevant. As the remote-controlled vessels are being operated by skilled operators ashore, they will have no real issues in complying with the steering and sailing rules of the COLREGs.

With fully autonomous vessels it's a different story. In the near future, it probably will be possible to integrate these sailing and steering rules into the algorithms of the systems operating the vessel autonomously. However, the issue comes with the application of the principle of 'good seamanship', as referred to in Rule 2(b) of the COLREGs. No experienced master is in charge of the ship when the ship comes in an exceptional dangerous situation, so it remains

²³⁰ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 46.

uncertain how autonomous ships will act in these situations. This uncertainty creates a feeling that autonomous vessels still aren't completely safe.

This uncertainty also causes some legal and practical concerns. As from a practical point of view, an autonomous vessel that may have difficulties in navigation through the more complex environments, and is more likely to have troubles in completing its journey safely. As such it is also more likely to collide with other objects at sea. And an increased probability of accidents goes together with a larger risk of incurring liability. As a consequence of an increased liability exposure, insurers could be more reluctant to cover autonomous vessels (or provide an insurance cover at a higher premium).

This somewhat explains why all the unmanned vessels that are currently being developed, are equipped with remote operation or hybrid systems, that enable human operators to take control of the navigation and to comply with the navigational rules.²³¹ But when looking at the future, I strongly believe that the continued research and testing will reach a point where fully autonomous vessels are able to comply completely with all the navigational rules.

4.4.2 SOLAS Convention

As mentioned before, the SOLAS Convention is one of the most important conventions regarding the safety at sea, with the purpose to regulate the minimum standards for construction, equipment and operation of vessels in order to guarantee their safety. Whereas Chapter V of the SOLAS Convention was discussed earlier under the chapter with regard to the manning of ships, this section will deal with the other chapters of the SOLAS Convention, concerning the operation of ships. In particular Chapter II-1, Chapter II-2, Chapter III, Chapter IV, Chapter VI, Chapter IX, Chapter XI-1 and Chapter XI-2 will be discussed with respect to the challenges they pose for unmanned vessels. The remaining chapters of the SOLAS Convention will not be reviewed, as they are ought to be applied on unmanned vessels, without posing any difficult problems.

²³¹ P.W. PRITCHETT, "Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology", *Tulane Maritime Law Journal* 2015, (197) 207.

4.4.2.1 Chapter II-1 and Chapter II-2

Chapter II-1 of SOLAS deals with the construction of ships, the subdivisions into watertight compartments, the stability of ships, machinery and electrical installation on ships. Chapter II-2 deals with the necessary measures for fire protection, fire detection and fire extinction on ships. Both chapters mostly regulate on how a ship should be constructed and what equipment the ship should have on board. Clearly, there is no reason why these chapters should not be applied on unmanned vessels. When a ship is being built, it must comply with certain stability requirements and features such as a double bottom or a double hull. The mere fact that the vessel suddenly becomes unmanned, does not justify neglecting these requirements, nor does it necessitate additional measures.²³²

Still, there will be some detailed provisions that will need to be adapted, in order to reach their purpose in unmanned ships. For instance, the monitoring systems, alarms and safety operating systems should be located in the SCC, and the term ‘navigating bridge’ should also refer to the SCC, so these provisions could keep their meaning for unmanned ships.²³³

It is also possible that a flag states decides to exempt a ship from the requirements in Chapters II-1 and II-2, if their application would seriously hinder the research on some innovative features.²³⁴ Or a flag state administration could accept an alternative solution if they decide that this solution would be at least as effective as the measure required by the convention.²³⁵ These provisions allow for some freedom for unmanned vessels in complying with the regulations of this chapter.

4.4.2.2 Chapter III

Chapter III (Life-saving appliances and arrangements) of the SOLAS convention extensively stipulates different obligations regarding the life-saving appliances and arrangements, such as the requirements for lifeboats, rescue boats and life jackets.²³⁶ In principle, unmanned vessels

²³² AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 42.

²³³ Ibid.

²³⁴ Reg. I/4 (b) SOLAS.

²³⁵ Reg. I/5 (a) SOLAS.

²³⁶ X, *International Convention for the Safety of Life at Sea*, [http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-\(solas\)-1974.aspx](http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas)-1974.aspx) (consulted 18 April 2017).

would also be subject to the application of this chapter. Nevertheless, the question arises whether unmanned ships should be equipped with life-saving equipment, even when there is not a single person on board.

The detailed list of equipment that a ship should have on board, is to accommodate the crew in case of distress.²³⁷ But, when we are talking about unmanned ships, there will be no crew, so on the one hand, the reasoning behind this SOLAS chapter would become obsolete. On the other hand, it could be that a vessel, without any lifesaving equipment on board, could be considered unseaworthy. But then again, installing all the equipment, survival crafts and rescue boats and so on, means extra costs that need to be paid for, just for the sake of being seaworthy. This would seem a bit useless.

Possibly Reg. III/2 could provide a solution as it foresees in the possibility to exempt individual ships or classes of ships from “*the application of any specific requirements of Chapter III that are considered unreasonable or unnecessary*”. This exemption still is rather limited because only ships that don’t proceed more than 20 miles from the nearest land in the course of their voyage can be exempted.²³⁸ Unmanned vessels are most likely to sail on international voyages, so they will probably not fall under this condition. Also, the exemption must be issued by the flag state administration²³⁹, while an international organization (like IMO), might be in a better position to issue a general exemption for unmanned ships.

Another point in question, is what when something would happen with a crewed vessel, and the SCC receives a distress call. The duty to provide assistance to vessels in distress in one of the oldest rules in maritime law, but what when the assisting vessel neither has a crew, nor the equipment to assist the vessel in distress? An unmanned vessel would not be able to help much to the crew in distress. Even in case unmanned vessels would be equipped with lifeboats, what if there are not enough boats available for accommodating the whole crew? Furthermore, unmanned vessels will not be designed to have a crew on board, so would it be appropriate to bring persons on board when there are no cabins, no heating, no clean water and no food on

²³⁷ M. CHWEDCZUK, “Analysis of the legal status of unmanned commercial vessels in U.S. admiralty and maritime law”, *Journal of Maritime Law and Commerce* 2016, 47, (1) 10.

²³⁸ Reg. III/2(1) SOLAS.

²³⁹ Reg. I/2(b) SOLAS.

board.²⁴⁰ Yet, it would still be more suitable than leaving those persons behind and letting them drown.

All these factors indicate that applying Chapter III on unmanned vessels, is not as straightforward as it would seem. On the one hand, it would be useless to carry lifesaving equipment on board because the vessel has no crew or passengers, while on the other hand the vessel should have certain equipment on board to assist the other crewed vessels in distress. Either a specific regulation or a severe revision of Chapter III, stipulating the appropriate lifesaving equipment, would be necessary to have specific rules applied on unmanned vessels, so they could become an added value to vessels in distress.

4.4.2.3 Chapter IV

Chapter IV of SOLAS stipulates the functional requirements regarding the radio communications of ships. Vessels should be set up with the necessary radio installations and equipment. Vessels should for instance be able to transmit and receive messages and distress alerts by at least two separate and independent means.²⁴¹ This and similar requirements are regulated in this chapter to improve the chances of rescue after an accident.

Unmanned vessels will in principle also be subject to the application of this chapter. In order to effectively comply with this chapter, the radio communication should be transmitted to the SCC, where there is personnel present with full knowledge of the vessel's whereabouts.²⁴² Aside from some minor modifications that might be required, Chapter IV is not supposed to form a big hindrance for the operation of unmanned vessels.

4.4.2.4 Chapter VI

SOLAS, Chapter VI handles the operational requirements for the loading, unloading, stowing and securing all types of cargo, which may require special precautions, due to their particular hazards to the ships or persons on board.²⁴³ These tasks must be well performed as they are

²⁴⁰ M. CHWEDCZUK, "Analysis of the legal status of unmanned commercial vessels in U.S. admiralty and maritime law", *Journal of Maritime Law and Commerce* 2016, 47, (1) 10.

²⁴¹ Reg. IV/4 SOLAS.

²⁴² AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 43.

²⁴³ Reg. VI/1 SOLAS.

crucial for the safety of the cargo and the stability and safety of the vessel. Therefore, this chapter should also be applied to unmanned vessels.

However, some of the regulated procedures require an active communication between the master, the shipper and terminal operator.²⁴⁴ Looking at the modern communication technologies, the communication between these parties should not form the real problem. The only thing that will differ with unmanned vessels, is that there will be no ship's master, bearing final responsibility for the safety of loading and unloading procedures.

This responsibility can probably not be transferred to the Manager or operators in the SCC, as they will not be travelling along with the vessel, so they are not able to control the loading, stowing and securing of the cargo. Hence the final responsibility of the safe loading and unloading procedures should be borne by someone who is closer involved to this operation, be it the shipping agent, a local representative of the SCC, or the terminal operators handling the cargo.

4.4.2.5 Chapter IX

Chapter IX incorporates the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM) code in the SOLAS convention, making it mandatory for all the signatory countries of the SOLAS. This Chapter applies to all commercial ships, so unmanned vessels will also be subject to its application.²⁴⁵ The ISM code was adopted in 1993 after some serious marine casualties that occurred in the 80's, that were caused by human errors or omissions. To decrease these errors, the ISM aims to achieve a bigger involvement of the shore-based company in the safety management of their individual ships.²⁴⁶

In order to guarantee safety and environmental protection by decreasing human errors, the ISM code requires shipowners and other persons responsible for the operation of the ship, such as managers or bareboat charterers (referred to as "the company"), to implement Safety Management Systems (SMS).²⁴⁷ The SMS is a written plan, adapted to a specific type of vessel,

²⁴⁴ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 43.

²⁴⁵ Reg. IX/2 SOLAS.

²⁴⁶ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 44.

²⁴⁷ A. J. NORRIS, *Legal Issues Associated with Unmanned Maritime Systems*, U.S. Naval War College, 2013, 52.

which contains the safety and environmental protection policies and procedures that need to be followed by the vessel and the shore-based crew. The SMS must foresee specific record keeping, reporting, and internal audit requirements so that “the company” is able to reveal and fix safety flaws.²⁴⁸ For unmanned vessels, it would be the SCC that is responsible for implementing a Safety Management System.²⁴⁹

As there will be no crew on board, some requirements of the ISM code will be more difficult to implement, such as the communication and reporting requirements, and the reference to the principles of safe manning.²⁵⁰²⁵¹ These provisions probably will become obsolete with regard to unmanned vessels. Also, the chance of human errors will already be significantly reduced in case of unmanned vessels and the link between the SCC operators and the vessel will also be tightened by technological means, which complies with the purpose of the ISM Code.

4.4.2.6 Chapter XI-1 and Chapter XI-2

Chapter XI-1 and Chapter XI-2 of the SOLAS convention both regulate some special measures to enhance the maritime safety. Unmanned vessels would be subject to the application of both chapters. Chapter XI-1 mainly regulates the requirements for organizations who carry out surveys and inspections on behalf of the national governments.²⁵² This chapter is unlikely to pose any difficulties for unmanned vessels.

Chapter XI-2 implements the International Ship and Port Facility Security (ISPS) Code and mainly deals with obligations for flag state administrations and the ship owning companies to ensure the security of ships and port facilities.²⁵³ In order to implement this Chapter on unmanned vessels, several modifications should be made to the provisions regarding the requirements of the ship’s master. Reg. XI-2/8 SOLAS stipulates for instance that the master has a final decision right, regarding the protection of the safety and the security of the ships.

²⁴⁸ A. J. RODRIGUEZ and M. CAMPBELL HUBBARD, “The International Safety Management (ISM) Code: A New Level of Uniformity”, *Tulane Law Review* 1998-1999, 73, (1585) 1595.

²⁴⁹ F. SAFARI and B. SAGE, *Legal and Liability Analysis for Remote-controlled Vessels*, MUNIN, 201319.

²⁵⁰ *Supra* 56.

²⁵¹ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 44.

²⁵² X, *International Convention for the Safety of Life at Sea*, [http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-\(solas\)-1974.aspx](http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas)-1974.aspx) (25 April 2017).

²⁵³ http://www.imo.org/blast/mainframe.asp?topic_id=897 (25 April 2017).

Again, due to the fact that there will be no master on board, this decision right should be transferred to the manager of the SCC.

If there would be no modification adopted, the national governments could make use of the possibility of agreeing on alternative security agreements. Reg. XI-2/12 gives a flag state administration the possibility to allow equivalent security measures for particular ships or type of ships, if these measures are at least as effective as those prescribed in the ISPS Code.²⁵⁴ These alternative arrangement or equivalent measures might be a good solution for applying security measures adapted to unmanned vessels.

4.4.2.7 Conclusion

First of all, all of the SOLAS chapters would be applicable to unmanned vessels. None of the chapters provide a stipulation that would exempt unmanned vessels completely of their application. Some of these chapters however give flag state administrations the chance to work out limited exemptions for certain types of ships. Using a broad interpretation, unmanned ships could be exempted from some requirements that would be unnecessary anyway.

Secondly, all of the SOLAS chapters will remain relevant to unmanned vessels in some way, for the reason that they all regulate different topics related to the safety of the vessels, and safety should at all-time remain a priority, whether the ship is manned or not.

Thirdly, none of the SOLAS chapters pose major issues when implementing them on unmanned vessels. Nevertheless, it would be preferable to fit different regulations to the characteristics of unmanned shipping. A distinction should be made between SOLAS provisions that may become obsolete/unnecessary/worthless and SOLAS provisions that require a modification to realize their purpose on unmanned vessels.

The first category of requirements are those that aim to protect the life of persons on board of (unmanned) vessels, for example some of the provisions of Chapter III. The second category of requirements are those of which the purpose remains relevant in unmanned shipping but

²⁵⁴ Reg. XI-2/12 SOLAS.

should be adapted so they can still achieve their intention. Examples of this category are the provisions referring to some tasks and responsibilities of the ship's master, like in Chapter VI.

4.5 Liability

4.5.1 Introduction

The autonomous technology is one of the hottest topics in the transport sector. A self-driving car brings you to work while you can still sleep in the backseat. An unmanned vessel sails on the ocean from the Far East to the Western ports to deliver tons of cargo. When the unmanned vessel has arrived in the port of destination, an automated crane is ready to unload the vessel. An autonomous truck brings these goods from the port to a distribution centre. And a drone will pick up your package at the distribution centre to deliver it in your backyard, by the time you are back home.

But what if; the drone drops the package on your neighbour's head; the automated crane releases a container on the cabin of a truck; the unmanned vessel collides with a manned vessel, damaging the carried cargo; or your driverless car runs over a bicyclist. The question that instantly raises is: "who is going to pay for this?".

One of the main concerns in different transport modes, still is the liability of autonomous vehicles. The technology of these autonomous systems is already there, but the legal framework still is a big question mark. The legal uncertainty with regard to the liability is holding the autonomous transport back. For that reason, the current regimes and ideas of liability in autonomous transport will be discussed first in this chapter. Secondly, the existing principles of liability in maritime law will be handled briefly. Thirdly, the possible solutions for establishing liability with unmanned vessels will be examined.

4.5.2 Liability of autonomous systems

As is the case with the current - human-controlled - vehicles, autonomous vehicles will most likely also be involved in accidents. But compared to current vehicles, human errors will rarely be the cause of the accident. Autonomous vehicles must be reliable and capable of driving in difficult circumstances at any time, without needing human intervention. Accidents with

autonomous vehicles will most likely be caused by defective products, hardware or software. Yet, the prevailing liability framework is mostly based on human acts or omissions.²⁵⁵

Today, the law does not provide specific answers for damages caused by autonomous systems, so we need to look at the existing rules to form a solution. The liability of autonomous products could be linked to different actors; the owner; the user; the manufacturer of the product or the manufacturer of individual components. When we look at autonomous transport from a technological point of view, autonomous systems of different transport modes perform in a similar way. Therefore, we will take a look at the liability concepts of unmanned aerial systems (or drones) and driverless cars.

4.5.2.1 Unmanned aerial systems

Unmanned aerial vehicles (UAV), better known as drones, are increasing in popularity, as well in civilian as in military applications. As for their civilian application, they can be used for commercial purposes such as recording, monitoring, surveying, transportation of cargo and maybe even passenger transport in the future, or for recreational purposes for photographing or as a ‘toy’.²⁵⁶

For the operation of drones, a similar distinction like unmanned vessels can be made. Drones will mostly be remotely controlled and operated by humans based on data collected through cameras, radars, satellites and/or other means. The other option is that a drone is operating autonomously, as a robot, based on pre-programmed commands or artificial intelligence and able to process the data from different sensors installed on the drone. In the last category, human intervention is not easily possible.²⁵⁷

While the increasing use of drones raises several concerns with regard to privacy, security and safety in air and on land, I will only discuss the liability framework of drones, in order to make a reference to the liability of unmanned vessels.

²⁵⁵ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 49.

²⁵⁶ K. BERNAUW, “Drones: The emerging era of unmanned civil aviation”, in N. RADIONOV (Ed.), *Collected Papers of Zagreb Law Faculty - Zbornik Pravnog Fakulteta U Zagrebu*, Vol. 66, (223) 228.

²⁵⁷ *Ibid*, 227.

4.5.2.1.1 *Cargo liability*

First of all, with drones, the liability of the carrier would be governed by the Montreal Convention²⁵⁸ or the Warsaw Convention²⁵⁹, for domestic carriage in Belgium for instance. The Montreal Convention regulates the international carriage by air, and stipulates the rules regarding the liability for damaged cargo and the liability limits. In case the cargo is damaged, which could either be a package delivery (like Amazon Prime Air²⁶⁰), or the camera equipment of a client, the carrier would be held liable for damages if they occurred during the period of the carriage.²⁶¹ This rule would and could still be applicable on drones without any real issues.

The main issue with regard to cargo liability of UAV's would be the applicable liability limitations. The Montreal Convention limits the liability of the carrier to 19 SDR or EUR 26.34 per kg.²⁶² In case a camera would be damaged, the victim would only be compensated for an amount of EUR 15-20, while the real damage suffered would be a lot higher. A contractual increase of the liability limits or an additional insurance would be required for the cargo- / camera-owner to avoid this risk.²⁶³

4.5.2.1.2 *Third party liability*

The third party liability of drones is somewhat less clearly regulated. Under international law, the Rome Convention²⁶⁴ is the relevant treaty that regulates the liability for damages caused by an aircraft registered in a foreign State. Belgium has extended the application of the Rome Convention to Belgian aircrafts.²⁶⁵ According to art. 2 of the Rome Convention, it is the “operator” of an aircraft who will be strictly liable to compensate the damage caused by the aircraft.

²⁵⁸ ICAO, Convention for the Unification of Certain Rules for International Carriage by Air, Montreal, 28 May 1999 (hereafter: Montreal Convention).

²⁵⁹ Convention for the Unification of Certain Rules relating to International Carriage by Air, Warsaw, 12 October 1929 (hereafter: Warsaw Convention).

²⁶⁰ <https://www.amazon.com/Amazon-Prime-Air/b?node=8037720011> (consulted 29 April 2017).

²⁶¹ Art. 18 Montreal Convention.

²⁶² Exchange currency d.d. 2 May 2017.

²⁶³ F. UNZ, “The commercial use of unmanned aerial vehicles under the current legal framework”, *Tijdschrift Vervoer & Recht* 2016, (4), (119) 124.

²⁶⁴ Convention on damage caused by foreign aircraft to third parties on the surface, Rome, 7 October 1952 (hereafter: Rome Convention).

²⁶⁵ Act 14 July 1966 houdende goedkeuring van het Verdrag betreffende de schade door buitenlandse luchtvaartuigen aan derden op het aardoppervlak veroorzaakt, *BS* 27 September 1966.

The operator is “*the person who was making use of the aircraft at the time the damage was caused*” and “making use” is defined as “*using it personally or when his servants or agents are using the aircraft in the course of their employment, whether or not within the scope of their authority*”.²⁶⁶ As for remote-controlled UAV’s, the person operating the drone remotely, clearly is the operator. However, for autonomous drones this is more ambiguous, because the drone is operating itself. In case of autonomous drones causing damage, it probably will be the owner of the drone who will be held liable as “*the registered owner of the aircraft shall be presumed to be the operator and shall be liable as such, unless he proves that some other person was the operator*”.²⁶⁷

Yet, because the Rome Convention was not designed to regulate drones, the same issue as with the Montreal Convention arises; the low liability limitations. The liability limits are based on the weight of the aircraft, which can be between 1-150kg for commercial drones. Therefore, drones would fall under the lowest category of liability limits, limited to an amount of 500,000 francs or EUR 12,394.²⁶⁸ So, in order to avoid the liability limitations, the victim could look for alternative means to claim compensation.

In case the damage was caused by a defect of the drone, the victim could ground his claim on art. 1384 C.C and claim compensation from the holder of the defective drone. The holder of drone could then take recourse against the manufacturer, based on product liability law.²⁶⁹ The victim could also claim directly compensation from the manufacturer based on the product liability act, if the damage was caused by a defective drone.²⁷⁰ The victim could claim compensation for injuries and material damages, without liability limitations.²⁷¹ Of course with the condition, that the drone was indeed defective. This is the case when a drone is not as safe as one can reasonably expect from a drone, taking all circumstances into consideration.²⁷² It

²⁶⁶ Art. 2.1 Rome Convention.

²⁶⁷ Art. 2.3 Rome Convention.

²⁶⁸ Art. 11 (a) Rome Convention.

²⁶⁹ K. BERNAUW, “Drones: The emerging era of unmanned civil aviation”, In N. RADIONOV (Ed.), *Collected Papers of Zagreb Law Faculty - Zbornik Pravnog Fakulteta U Zagrebu*, Vol. 66, (223) 245.

²⁷⁰ Act 25 February 1991 betreffende de aansprakelijkheid voor producten met gebreken, *BS* 25 February 1991 (hereafter: Product Liability Act).

²⁷¹ Art. 11 Product Liability Act.

²⁷² Art. 5 Product Liability Act.

should be noted that a product cannot be qualified as defective, only because a newer / better product has entered into the market^{273, 274}.

4.5.2.1.3 Drone insurance

Belgium has also adopted a Royal Decree on the use of remote-controlled aerial vehicles in the Belgian Airspace.²⁷⁵ This royal decree regulates the recreational and professional use of drones in the Belgian Airspace in order to guarantee the safety and the privacy of citizens. The Drone Decree requires that the operator, using a remote-controlled UAV for professional or commercial purposes, must be insured for third party liability in accordance with the minimum requirements of art. 7 of the European Regulation on insurance requirements for air carriers and aircraft operators.²⁷⁶ The operators of a drone for recreational purposes must also take out an insurance for civil liability, in order to cover material and personal damages of third parties.²⁷⁷

As the Drone Decree is only applicable on remotely operated UAV's, and not on autonomous UAV's, it assumes that in most cases the operator of the UAV will be held liable. There is no provision that a manufacturer should take insurance cover for his third party liability. Also, as there will still be a human operating the UAV, the damage is more likely to be caused by an error or negligence of the operator, than a defect of the UAV itself.

4.5.2.1.4 Conclusion

The increasing use of drones for numerous purposes has raised a lot of questions with regard to security, safety and privacy. As for the liability for damages caused by UAV's, different regulations are in place. In case the drone is carrying cargo or equipment, it will be the carrier who is strictly held liable. If the drone would cause damages to a third party, it will be the operator who is strictly held liable in case of a remote-controlled UAV, or the registered owner in case of an autonomous UAV. In both cases, the liability of the carrier / operator / registered owner will be limited to a rather low amount, due the fact that the applicable conventions were

²⁷³ Art. 5.1 Product Liability Act.

²⁷⁴ W. VERHEYEN, "Onbemande luchtvaartuigen: Vogelvrij of (nu al) gekooid?", *NJW* 2015, (338) 344.

²⁷⁵ R.D. 10 April 2016, on the use of remote-controlled aerial vehicles in the Belgian Airspace, *BS* 10 April 2016 (hereafter Drone Decree).

²⁷⁶ Reg. EP and Council no. 785/2004, 21 April 2004 on insurance requirements for air carriers, *Pb.L.* 30 April 2004, 138, 1.

²⁷⁷ Art. 97 Drone Decree.

not designed for UAV's. To avoid these limitations the victim could ground his claim on general liability or product liability law against the holder, respective manufacturer.

4.5.2.2 Autonomous cars

Sooner or later, autonomous cars will appear on our roads. Car manufacturers and tech companies are cooperating and competing against each other to be the first one to bring their autonomous car into the market.²⁷⁸ Self-driving cars would make driving much safer because they are able to see things that a human driver can not, and they eliminate the risk of human errors, which is the major cause of all car accidents happening today. Yet, assuming that taking humans away from behind the wheel would result in no more accidents, might be too optimistic, for now.

The less cars need to rely on a human driver's input, the more risk will be linked to the car technology itself. As every other piece of technology, car technology is also likely to fail. Moreover, we need to bear in mind that car technology can only be as good as their developers and programmers. And with the increased complexity of systems, more things can go wrong.²⁷⁹

As with traditional cars, the biggest risk of a malfunctioning autonomous car is that it would cause an accident, leading to damages, injuries and casualties. It is even plausible that when the autonomous technology becomes defect, it would result in more severe collisions. Because some reason that, humans can cause severe accidents trough errors or negligence, but it's rarer that a human would carry out a manoeuvre which is completely breaching all rules of road safety, like driving on the wrong side of the highway.²⁸⁰

No matter how safe autonomous cars might be, or how severe the accidents they might cause, there must be a legal framework for the liability of autonomous cars. Therefore, we will take a brief look at the current ideas and principles related to the self-driving cars and the liability aspects.

²⁷⁸D. MUOIO, *19 Companies racing to put self-driving cars on the road by 2021*, <http://uk.businessinsider.com/companies-making-driverless-cars-by-2020-2016-10?r=US&IR=T/#uber-released-its-autonomous-cars-in-pittsburgh-as-part-of-a-pilot-program-in-september-2> (consulted 3 May 2017).

²⁷⁹ G. YEOMANS, "Autonomous Vehicles. Handing over control: opportunities and risks for insurance", London, Lloyd's, 2014, 15.

²⁸⁰ Ibid.

4.5.2.2.1 Liability of autonomous cars

To be clear, there are different levels of car automation and autonomous driving is the most advanced level of car automation. The distinction of different levels which is made in part 2.1.1, is relevant for the liability.²⁸¹ Today, cars are being manufactured and brought into the market with a gradually increasing level of automation (until the 3rd level). As long as a vehicle is partially autonomous (Level 1-3), the driver remains responsible for taking over and controlling the vehicle. As from the 4th level, the responsibility of driving safely and avoiding accidents is completely shifted to the autonomous car system and all of its components.²⁸²

As long as a car is offering some automated functions (Level 1-3), the human driver will still be held liable in most cases. The driver can be held liable on a fault based liability if he committed an error or if he was negligent (art. 1382 C.C.), for instance when he would badly rely on his parking sensors and hit the car behind him. He will also be held liable if he would hit a car using the (defective) automatic parking function of his car, based on the fact he is the holder of a defective product (art. 1384 C.C.).²⁸³

If a collision would be caused by a vehicle operating fully autonomous (4th level), where a driver has no responsibility of taking control of the vehicle, the current regime of fault-based liability (as in art. 1382 C.C) would be difficult to apply, because the driver/user did not do anything wrong.

Also, if an accident does occur in an autonomous car, it's most likely that something went wrong with the technology or software of the car, which indicates a defect in the manufacturing, programming or design of the autonomous car. In such case, several parties could be held liable: the car manufacturer; the manufacturer of a certain component; or a software engineer who designed or programmed the code for the autonomous operation. In a fault-based liability regime, the victim would need to find out who made the error in designing/programming/manufacturing. However, most people do not have enough

²⁸¹ Supra 4.

²⁸² G.E. MARCHANT and R.A. LINDOR, "The coming collision between autonomous vehicles and the liability system", *Santa Clara Law Review* 2012, (1321) 1326.

²⁸³ J. TANGHE and J. De BRUYNE, "Aansprakelijkheid voor schade veroorzaakt door autonome motorrijtuigen", *RW* 2016-2017, (963) 974-983.

technological expertise to proof a technical defect, let alone to prove who was responsible for the defect. Therefore, a presumed-fault liability regime might be more victim-friendly.²⁸⁴

In most cases, it will then be the car manufacturer who will be presumed liable for damages caused by a fully autonomous vehicle due to both practical and legal reasons, based on product liability laws. From a legal perspective, a car manufacturer is liable for his defective product. If it seems that a defective component of the car or its software was caused by another party, he could take recourse against this party. As for the practical reasoning: the car manufacturer is generally spoken also the one who is financially solvable enough to bear the compensation of losses.²⁸⁵

For these reasons, some predict that the autonomous technology in cars will shift the way we think about accident responsibility. Instead of directly attributing the accident to the driver, we may be more tempted to blame car manufacturers for defective cars or technology.²⁸⁶ Because of this, car manufacturers could become reluctant to introduce their autonomous cars. However, it's more likely that the manufacturers will incorporate the increased liability risk in the price of autonomous cars. Or that the customers pay an additional price to car manufacturers to take out an insurance for their car. So ultimately, the cost will be passed on to the customers.²⁸⁷

4.5.2.3 Conclusion

The overview of liability regimes above, can give an idea on how we should handle the liability with unmanned vessels. As with UAV's delivering cargo, the carrier will still be held liable for damages to cargo or equipment. And in case a UAV would cause damage to a third party, it will be the operator who will be liable in case of a remote-controlled drone, or the registered owner in case of an autonomous drone. Similar arrangements can be applicable on unmanned vessels. The compulsory liability insurance of drone owners, is something which already is obligated in maritime law.

²⁸⁴ Ibid, 1327.

²⁸⁵ Ibid, 1328-1329.

²⁸⁶ M. ANDERSON, N. KALRA, K. D. STANLEY, P. SORENSEN, C. SAMARAS, O. A. OLUWATOLA, *Autonomous Vehicle Technology: A guide for policymakers*, Santa Monica, RAND Corporation, 2016, 141.

²⁸⁷ Ibid, 141-142.

With autonomous cars, the distinction between a car with automated functions and a fully autonomous car is important. In a car with automated functions the driver can still be held liable for the damages he caused, albeit on a fault-based liability or based on vicarious liability. With autonomous cars, the driver is not controlling the car, so a collision will in most cases be caused by a defect of the car or its software system, leading to the liability of the car manufacturer, the software designer, or programmer. This distinction of different liabilities could also be applied on the distinction between remote-controlled and autonomous vessels.

4.5.3 Liability of unmanned vessels

In this section, we will return back to the maritime transport mode. In particular, the liability regimes in maritime law will be briefly handled in this section. The principles will be handled according to the Belgian maritime law, as there is no uniform convention regulating the maritime liability. The issues of maritime liability are largely based on national legal systems and traditions. Discussing all these national variations would lead us too far and would be irrelevant as well. The global purpose is to look at how unmanned vessels can fit into the liability laws.²⁸⁸ First we will take a look at the contractual liability regime and then the extracontractual liability regime will be handled. If relevant, the distinction between autonomous and remote-controlled vessels will be mentioned.

4.5.3.1 Contractual liability

In merchant shipping two contracts are very important; the charter party and the contract of carriage. Both contracts will be discussed.

4.5.3.1.1 Charter party

The charter party is the private contract used for the hire of an entire vessel. The shipowner supplies the ship and the charterer or carrier obtains the use and service of the ship. The ship can be hired for a fixed period (time charter), for a single voyage (voyage charter), or the charterer can opt for obtaining complete control of the vessel, whereby he is considered as legal owner of the vessel (bareboat or demise charter).²⁸⁹

²⁸⁸ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 50.

²⁸⁹ T.J. SCHOENBAUM, *Admiralty and Maritime Law*, St. Paul, West, 2001, 630.

Charter parties can continue to exist without any constraints for unmanned vessels. The fact that there is no crew on board anymore, does not change anything to the charter party or to the obligations of the shipowner and charterer.

Some minor adaptations in the contract might still be required, such as defining who is responsible for employing/hiring the shore-based controllers in case of a remote-controlled vessel. In cases of a time or voyage charter, it will be the owner who contracts with the SCC, whereas in case of a bareboat charter, it will be the charterer who will need to do this.²⁹⁰ Again, this doesn't differ much with the current situation on who is responsible for recruiting a crew. So, charter parties and their liabilities will barely be influenced by the introduction of unmanned vessels.

4.5.3.1.2 *Contract of carriage*

Unmanned vessels will in the first place be used in merchant shipping, and especially in the transportation of goods, which means that contracts of carriage will be closed between carrier and shipper. The obligations of the carrier and shipper will be laid down in a bill of lading or a similar document, governed by an international convention such as the Hague-Visby Rules²⁹¹, the Hamburg Rules²⁹² or the Rotterdam Rules²⁹³.

The carrier is held to ensure that the vessel is seaworthy²⁹⁴ and is bound to bring the complete cargo intact to its destination within time. The carrier will be held liable if the delivery of cargo is damaged, lost or delayed²⁹⁵, caused by fault of the carrier or his servants or agents²⁹⁶.²⁹⁷ The carriage of goods by means of an unmanned vessel does not change anything to the duties of the carrier. In case the cargo would be damaged, lost or delayed due to an error of the

²⁹⁰ E. VAN HOOYDONK, "The law of unmanned merchant shipping", *The Journal of International Maritime Law* 2014, (403) 418.

²⁹¹ International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading, Brussels, 21 December 1979 (hereafter: Hague-Visby Rules).

²⁹² UN Convention on the Carriage of Goods by Sea, Hamburg, 31 March 1978 (hereafter: Hamburg Rules).

²⁹³ UN Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea, Rotterdam, 23 September 2009 (hereafter: Rotterdam Rules).

²⁹⁴ Art. 3.1 (a) Hague-Visby Rules; Art. 14 (a) Rotterdam Rules.

²⁹⁵ Not according to the Hague-Visby Rules

²⁹⁶ Not according to the Hague-Visby Rules

²⁹⁷ Art. 4 Hague-Visby Rules; art. 5 Hamburg Rules; art. 17 Rotterdam Rules.

autonomous vessel, the carrier still will be held liable, because he must make the autonomous vessel seaworthy, which implies that all the radar and sensor installations, as well as the guiding IT systems and software should function properly.²⁹⁸

With remote-controlled vessels, the SCC will be operating and controlling the vessels, working on behalf of the carrier, as a servant or agent. In the realistic case where they would make a mistake, resulting in damage, loss or delay, again the carrier will be held vicariously liable. Under the Hague-Visby rules, he may be exonerated based on the error in navigation or management of the ship, committed by his servants (assuming that the SCC will operate as a servant of the carrier).²⁹⁹

So all in all, the carriage of goods by unmanned ships, remote-controlled or autonomous, will not change much to the liability risks of the carrier.

4.5.3.2 Extracontractual liability

This section will handle who will be held liable in case an unmanned vessel would cause damage to third parties. Generally maritime law will channel the liability to the owners or operators of the ship, instead of individual crew members or assistants. In a number of accidents, the shipowner will be held vicariously liable for damages caused by errors (breaching certain regulations such as the COLREGs) or negligence of his servants and agents and damages due to the unseaworthiness of the ship. The identity of the person who committed the actual error mostly isn't the concern of the claimants, as they can claim compensation from the shipowner, based on his vicarious liability. Assumingly, this will remain the case with unmanned vessels. However, who has committed the error or negligence might be of interest for the shipowner, so he is able to take recourse.³⁰⁰

Unmanned vessels will be able to shrink the main cause of maritime accidents, the human error. However, this does not imply that there will be no more maritime accidents in the future. Unforeseen issues can always arise, like a collision due to defective navigation equipment or

²⁹⁸ E. VAN HOOYDONK, "The law of unmanned merchant shipping", *The Journal of International Maritime Law* 2014, (403) 419.

²⁹⁹ Art. 4.2 (a) Hague-Visby Rules.

³⁰⁰ AAWA, *Remote and Autonomous Ships: The next steps*, London, Rolls-Royce plc, 2016, 51.

due to loss of connection, leading to personal injuries and material damages. Victims will try to claim compensation from the shipowner, who on his turn will try to rebut his liability or take recourse against another liable party.³⁰¹

Although maritime liability law does not necessitate a serious reform, the increased level of automation still poses some challenges for the current liability framework. The distinction between autonomous vessels and remote-controlled vessels is highly relevant for establishing liability.³⁰² Therefore, they will be handled under separate titles. Due to the fact that maritime liability law is generally regulated on a national level, this part will be handled from the perspective of Belgian law.

4.5.3.2.1 Third party liability of autonomous vessels

Autonomous vessels do not require human intervention or assistance to navigate. If such a vessel would collide, it would be troublesome to appoint the person who had committed an error directly in relation with the damages. The autonomous technology may come together with new errors or malfunctioning technologic systems. A system failure or faulty software could cause the autonomous vessel to deviate from its safe route and crash into another (manned) vessel. The shipowner or operator will be held liable, based on art. 1384 C.C, as he is the holder of the defective autonomous vessel, regardless of any fault.³⁰³

If the vessel owner is liable, every time his autonomous vessel would cause damages, due to failures, he will become reluctant to purchase and/or use his autonomous vessel. Then, costs of liability risks will increase and his insurance premium will become more expensive, which may result in higher freight rates. Because of these reasons, it could be that in the future, there will come a shift to product liability for autonomous vessels, like in the autonomous car industry. When these vessels would cause damages or injuries due to a defect in the sensors, radars, IT systems, or other technologic components, a claimant could choose to claim compensation from the manufacturer of these parts, based on product liability law.

³⁰¹ M. CHWEDCZUK, “Analysis of the legal status of unmanned commercial vessels in U.S. admiralty and maritime law”, *Journal of Maritime Law and Commerce* 2016, 47, (1) 11.

³⁰² *Supra* 2.

³⁰³ Or similar national grounds of vicarious liability.

According to art. 1 of the European Product Liability Directive³⁰⁴ the producer shall be liable for the damage caused by a defect in his finished product or component part. This is a strict liability regime, so the claimant does not have to prove any fault or negligence of the producer, only his damage, the defect and the causal relationship.³⁰⁵ As opposed to the shipowner, the manufacturer will not be able to limit his liability based on the LLMC Convention³⁰⁶, which will be beneficial for the claimants.

However, still today there is some discussion whether software and IT systems can be qualified as a ‘product’ within the meaning of art. 2 Product Liability Directive and art. 2 of the Belgian Product Liability Law³⁰⁷. The Product Liability Directive defines a product as “*all movables, with the exception of primary agricultural products and games, even though incorporated into another movable or into an immovable*”, whereas the Belgian Product Liability Law defines a ‘product’ more strictly as “*all tangible movables, even though incorporated ...*”. Then, it comes down to the question whether software can be seen as a tangible good or not.

- The Product Liability Directive has however expressly qualified ‘electricity’ as a product to evade the debate about tangible or intangible goods. This shows that the redactors of the directive wanted to create a rather extensive scope of application, back in the eighties. Through a teleological interpretation it is then plausible that software will eventually also fall under the application of the directive. Unfortunately, the European Court of Justice has not given any clarity on this issue.

In 1989, the European Commission has stated that software, stored on a tangible medium, is a product under the directive.³⁰⁸ In 2016, the EC has announced that it is going to evaluate the Product Liability Directive to assess whether the directive is fit-for-purpose vis a vis the new technological developments, such as; software, the Cloud,

³⁰⁴ Council Directive no. 85/374/EEC, 25 July 1985 on the approximation of the law, regulations and administrative provisions of the Member States concerning liability for defective products, *Pb.L.* 210/28, 29. (hereafter Product Liability Directive).

³⁰⁵ Art. 4 Product Liability Directive.

³⁰⁶ Convention on Limitation of Liability for Maritime Claims, London, 19 November 1976 (hereafter: LLMC Convention).

³⁰⁷ Wet 25 February 1991, betreffende de aansprakelijkheid voor producten met gebreken, *BS* 22 March 1991 (hereafter: Belgian Product Liability Law).

³⁰⁸ EC, written question 706/88, *Pb.L.* 114/42, 8 May 1989; J. TANGHE and J. DE BRUYNE, “Aansprakelijkheid voor schade veroorzaakt door autonome motorrijtuigen”, *RW* 2016-2017, (963) 978-979.

Internet of Things, advanced robots and automated systems. One of the issues that will be researched, is whether unintended autonomous behaviour could be considered as a defect.³⁰⁹ The results of this evaluation, will be of significant importance for the liability regime of autonomous vehicles and vessels.

- The Belgian Product Liability Law is even more strict as it requires that a product is a tangible movable good. Some claim that software is an intangible good, as it is only a collection of data and commands. Yet, others state that software is a tangible good because it can be put on a tangible portable device, such as a CD-ROM or a USB drive. And some others declare that software is tangible because it is part of the material reality, as opposed to philosophical or political ideas. Due to this uncertainty, the Belgian Judge should ask a prejudicial question to the European Court of Justice, when he has to deal with such a case.³¹⁰

Up till now, there is some consensus that software, materialised in a tangible medium, is a product. If the software is incorporated into a tangible good, in a way that it can hardly be distinguished from that good, like software necessary for the operation of a good, it must be viewed as a product that falls under scope of the Product Liability Directive. In such case, the operation software for unmanned vessels, can be considered as a product, because the software is an integral element of the good.³¹¹

If software and other IT systems of autonomous vessels would fall under the Product Liability Directive, this could reduce the liability risks that shipowners could incur when these vessels would have some defective components, causing damage. Especially because the Product Liability Law is more beneficial for victims due to its strict liability regime and the absence of a liability limitation. Product manufacturers on the other hand, are likely to face more and more

³⁰⁹ EC, Evaluation of the Directive 85/374/EEC concerning liability for defective products, 12 September 2016,

http://ec.europa.eu/smartregulation/roadmaps/docs/2016_grow_027_evaluation_defective_products_en.pdf (consulted 9 May 2017).

³¹⁰ J. TANGHE and J. DE BRUYNE, “Aansprakelijkheid voor schade veroorzaakt door autonome motorrijtuigen”, *RW* 2016-2017, (963) 979.

³¹¹ D. FAIRGRIEVE, G. HOWELLS, P. MØGELVANG-HANSEN, G. STRAETMANS, D. VERHOEVEN, P. MACHNIKOWSKI, A. JANSSEN and R. SCHULZE, “Product Liability Directive”, in P. MACHNIKOWSKI (ed.), *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies*, Antwerp, Intersentia, 2016, 47.

liability claims. The latter could fairly increase the importance of a product liability insurance for manufacturers of these components, looking at the liability claims in the maritime industry.

4.5.3.2.2 Third party liability of remote-controlled vessels.

Despite possibly being safer than the traditional manned vessels, remote-controlled vessels may still be causing some damages or injuries, as well as autonomous vessels. Contrary to autonomous vessels however, there still is a human factor involved in the operation of remote-controlled vessels, namely the operators in the SCC. This implies that there still exists a risk of human errors. That is why we need to take a look at how errors or negligence of the operators will or could be handled in a liability regime.

It should be noted that, remote-controlled vessels could also have a defect in their IT system or software, causing damages and leading to product liability. This will not be discussed under this title, because it will be similar to autonomous vessels. This title will only handle who will be held liable for errors in the operating and controlling of the remote-controlled vessel.

Traditionally, the shipowner will be held liable for the acts and omissions of the captain and his crew, based on art. 46 M.C. This vicarious liability is regardless whether the shipowner is their employer or not. With the operators controlling the vessel from ashore, it is likely that this will still remain the case.

Suppose that the persons in the SCC commit an error (breaching the COLREG Rules for instance) or negligence, leading to the ship causing damages. In the first place, victims will want to claim compensation from the shipowner, as he will be the more solvent party. If the persons in the SCC are equalized as captain and/or crew, the shipowner will be held liable based on art. 46 M.C. If they are bound by an employment contract with the shipowner, the shipowner will be held liable as their employer. Even if they are not bound by an employment contract, the shipowner will be held liable based on his broad vicarious liability.

It could also be possible that the remotely operating of ship becomes a new service, as a contractor or sub-contractor for one or multiple shipowners. If this would be the case, it may be appropriate to adopt new rules. An international convention or specific standard contracts

should be drafted in order to divide the different responsibilities and duties, as to determine who would be liable for what type of errors and damages.³¹²

4.5.4 Conclusion

Although unmanned vessels are predicted to be much safer than manned vessels, we cannot be too optimistic about this and need to face the fact that sooner or later, unmanned vessels will also cause accidents, leading to liability. The trend of automated and autonomous systems in all different transport modes raises questions with regard to liability.

With regard to the contractual liability, it's not expected that there will be serious changes required. The charter party can still be used with unmanned vessels, only some minor adaptations might be desirable. The contract of carriage of goods by sea can also still be applied with the for carrying goods with an unmanned vessel. The carrier will still be held liable for damage, loss or delay in the delivery of goods, regardless whether this was caused by an error of the shore-based personnel or a malfunctioning in the IT system of the vessel.

Things are different concerning the extra contractual liability in maritime law. Over time, as more and more vessels will become autonomous or remote-controlled, the maritime liability law is likely to undergo some changes. In first place these changes will probably come slightly into being through (inter-)national case law, and in the future through the adoption of new regulation.

Comparable to the situation with self-driving cars, it is highly possible that the relevance of product liability of different manufacturers will increase significantly. In the near future, manufacturers of IT systems and software designers may be held liable for damages caused by a defect in their components, that are installed in the vessel. This would be more advantageous for claimants, due to the strict liability regime and the absence of a liability limitation. Nevertheless, it might be that the European directive on product liability and national liability law require some modification in this regard. At least some clarity would be helpful for future claimants.

³¹² E. VAN HOOYDONK, "The law of unmanned merchant shipping", *The Journal of International Maritime Law* 2014, (403) 418.

It seems that the shipowner would also keep his broad vicarious liability with unmanned vessels. The compensation for damages or injuries, caused by fault or negligence of the shore-based personnel controlling the vessel, could still be claimed from the shipowner. This is also more interesting for claimants, considering that the shipowner will also be the more solvent party. On the occasion that the SCC would organize itself as service provider, operating independently from the vessel owner, new challenges and questions could come into being. New regulations or standard contracts could provide a solution for this.

4.6 Other potential issues

This paper has given an overview of which regulations may or may not form a legal challenge for unmanned vessels. Still, there are a number of unanswered questions when applying maritime law on unmanned vessels. For this reason, this last part will briefly assess some aspects of maritime law, which may or may not become a challenge for unmanned vessels.

General average is the act when any extraordinary sacrifices or expenses are intentionally made or incurred in the common interests of the maritime journey. In that case, the sacrifices and expenses shall be borne by the different interests.³¹³ It is likely that an unmanned vessel needs to deviate from its route to call in a port of refuge, or the cargo is remotely jettisoned, under the conditions of general average. The three interests of the maritime journey (shipowner, cargo owner and freight) would still remain the same with unmanned vessels. One of the implications of unmanned vessels may be, that there is no reason to include the crew wages of the SCC as general average, seen that the crew will probably be working on multiple 8-hour shifts anyway.³¹⁴ Aside from this, the general average arrangement doesn't seem to create large difficulties for unmanned vessels.

Another undiscussed topic is how the salvage rules³¹⁵ will apply on unmanned vessels, when they would come into distress. For instance, who will have the authority to conclude the salvage contracts? Probably the SCC will need to do this remotely and will also need to cooperate, to the extent that this is possible. And would the SCC be able to claim a salvage fee for this? Probably not as they are not involved in any dangerous rescue situations, sitting at their desks ashore. Furthermore, are the unmanned vessels subject to duty to rescue persons in distress at sea? And should they be equipped for that? Probably not, as the costs for installing such infrastructure will be much higher than the chance that they are actually involved in such situation.

Unmanned vessels will also get in to the sight of pirates. The good news is that unmanned vessels will not be vulnerable to the type of piracy where they take the crew hostage for obtaining a ransom. The bad news is that, due to their ICT systems, unmanned vessels may be

³¹³ Rule A, York Antwerp Rules 2016.

³¹⁴ E. VAN HOOYDONK, "The law of unmanned merchant shipping", *The Journal of International Maritime Law* 2014, (403) 422.

³¹⁵ International Convention on Salvage, 28 April 1989, London.

more vulnerable to the type of piracy where pirates try to steal the cargo and/or kidnap the ship for a ransom. By way of a cyberattack, pirates would be able to operate and manipulate the attacked vessel. The cybersecurity on unmanned ships will have significant influence in the fighting against piracy. But will these cyberattacks be considered as piracy, as there is no ‘*act of violence or detention*’?³¹⁶

Another aspect which may undergo some changes is marine insurance. As unmanned vessels could cause a shift towards product liability, this could influence the marine insurance. Will the manufacturers be required to close a liability insurance? And will claimants have a direct action right against these insurers? As one will notice, there are still a lot of unanswered questions, which need to be resolved over time.

³¹⁶ Art. 101 UNCLOS.

Part 5 Conclusion

Unmanned shipping is no longer a futuristic concept. The number of projects researching unmanned ships are increasing and the current results already are promising. Unmanned ships may initially be expensive, but they have numerous cost-saving effects, they increase safety of shipping and will be more environment friendly. Within several years, the first unmanned merchant ships will be ready to depart on their first journey. But the legal framework also needs to be prepared.

Unmanned ships will be subject to all the same conventions that are applicable to traditional ships. Of course, at the time of adopting these conventions, there was no sign of unmanned ships, which makes it sometimes troublesome to apply them on unmanned vessels. Overall most conventions don't require a total reform but some of them will require some (minor) modifications for unmanned shipping.

There are some differences with traditional shipping that will also have their impact on the legal setting. One of them is the difference between the traditional crew on board a ship and the shore-based personnel operating a remote-controlled vessel. Due to the different circumstances, I believe that the personnel in a SCC ashore will not have the same statute, powers and duties as the ship's master and the sailing crew. Due to this, the STCW convention, the MLC and the SOLAS convention (in particular the minimum manning requirements) might require some adaptations.

Another important evolution is that the traditional tasks of the crew will be taken over by different sensors, radars and IT systems. These technologies will be able to perform most of the navigational tasks, such as the lookout, in a more profound, reliable and safe way. The COLREGs rules should also be adapted so it would be allowed to carry out these navigational tasks by these systems. Also, the SOLAS convention should be adapted to these technologies, as they are fit for the purpose of SOLAS, but use a different way of performance.

And lastly, it seems that autonomous transportation modes will cause a shift in the current liability regime. While contractual liability will not be influenced by this, the extra-contractual liability could be undergoing some real changes. The current regime of shipowners' liability

may transform into liability of manufacturers and designers, based on product liability law, even though product liability law requires some adaptations for unmanned ships. Next to these parties, shipowners still can be held vicariously liable for damages caused by their ship.

This dissertation has assessed some of the legal challenges of unmanned ships. However, there are still several other issues which need to be analysed. Unfortunately, the size of this dissertation is insufficient to handle all of them. Also, a lot of issues will only be discovered once unmanned vessels are already operational. Until that day, we can only wait and watch eagerly at how technology is changing the global shipping industry.

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