LEGAL CHALLENGES OF LIABILITY IN COLLISIONS ARISING FROM THE DEVELOPMENT OF AUTONOMOUS AND UNMANNED SHIPPING

INTERNATIONAL AND NORWEGIAN PERSPECTIVE

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1 Introduction

1.1 Autonomous navigation as a reality

Autonomous shipping has been one of the most regular topics in congresses, papers, studies and thesis for the past years within the maritime industry. Technological developments have led to make unmanned vehicles a reality, and therefore numerous discussions and debates have arisen regarding the regulatory and legal aspects of this new development.

According to the ICS, the shipping industry “is responsible for the carriage of around 90% of world trade”. Thus, shipping plays an essential role in intercontinental trade, not only with the transport of final products or goods for consumption, but with the transport of raw materials for production. As a consequence thereof, maritime industry has been facing an important challenge to design more effective ways of transportation, as well as the introduction of new technologies that enhance the performance of the vessels.

In an effort to reduce complexity during voyages and to increase safety and efficiency in the operation of the vessels, many companies worldwide started to develop new technologies to make unmanned and autonomous ships a reality.

Autonomous shipping is an emerging trend in one of the world’s most ancient industries and automation of processes and voyages will eventually transform the paradigm of trading by sea.

In December 2018, the company Rolls-Royce jointly with Finferries deployed and demonstrated the navigation of the first fully autonomous ferry “Falco” in Turku, Finland. In the words of the President of Commercial Marine of Rolls-Royce, this deployment confirms the fact that autonomous shipping is already a reality.

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1 See http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade (Last visited October 2018)
2 Finferries is a state-owned operator of ferry services in Finland.
Together with Finland, Norway is one of the countries that has openly accepted its interest in implementing unmanned shipping as a short-term reality, with many ongoing projects in the country. In 2013 the NFAS was established as a way to inform the industry on the advances and main trends in unmanned shipping. The forum allows companies and specialists from all over the world to discuss the challenges and opportunities of unmanned vessels.

Additionally, the Norwegian vessel Yara Birkeland which is the world’s first electric and autonomous containership, is already in the testing phase and will start operations in 2020. The purpose of this vessel is to transport Yara’s products from their production plant in Porsgrunn to Brevik and Larvik, Norway. The project foresees the gradual implementation of automation to its transport operations. The first part will involve the testing of the ship with a master and a small crew on board, in order to continue with remote-controlled operations and finally the complete automation of the vessel in 2022.

Due to the aforementioned, it is more than relevant to assess and analyze Norway’s domestic legislation, as the first autonomous vessels are to be launched within its national waters.

As seen, unmanned vessels and autonomous ships are already a reality, and not only a trend or a science plan to be developed. This is a huge step for the maritime industry that will completely change business as usual, especially, in the logistic and transportation areas; bringing enormous benefits regarding efficiency and speed of the operations as well as better ways to protect the environment and reduce carbon emissions. In comparison to conventional maritime shipping, the implementation of these systems will improve safety and costs but will also imply the creation of new risks.

Developing and agreeing on possible regulations applicable to unmanned and autonomous shipping, not only from a domestic perspective but also from an international point of view, has been a priority for international organizations and maritime countries.

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1.2 Scope of study

When analyzing the benefits and risks that will come with the navigation of remotely controlled and partially or fully automated and unmanned vessels, regulation of collisions for these specific types of vessels requires specific attention. Despite the enormous improvements in ship equipment and technology throughout the years, the number of collisions has not decreased significantly\(^5\), and this situation leads to the assumption that autonomous and unmanned navigation will trigger additional risks.

This thesis will begin with the study of international conventions and regulations in order to determine if they allow the existence and navigation of autonomous vessels within the shipping industry, starting with the UN Convention on Law of the Sea (1982), the International Regulations for Preventing Collisions at Sea (1972) and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (1978).

With respect to collisions, the Convention for the Unification of Certain Rules of Law with respect to Collisions between Vessels (1910) as well as the domestic legislation for collisions among ships in Norway are analyzed, *i.e.* Norwegian Maritime Code and Norwegian case law. For the analysis of each of these legal instruments, the rules of liability arising from collisions between ships regarding traditional vessels are studied first and then all considerations related to autonomous/remote controlled vessels are later addressed -such as level of care, liability allocation-. The various levels of autonomy in each of the moments of navigation shall be distinguished.

Following this analysis, the results obtained will provide the grounds to determine:

a) First, whether the current legal framework allows autonomous vessels to navigate; and,

b) Second, if the current ship-to-ship collisions liability rules can be applied to autonomous or unmanned navigation or if such a framework requires amendments or clarifications in order to make it consistent with the new features of these types of vessels.

The purpose of this thesis is twofold. First, to analyze the most relevant legal issues that may arise from collision situations of autonomous and unmanned vessels from an international and domestic perspective. Second, to assess whether the current rules are capable of facing the legal challenges of autonomous vessels or if it is necessary to seek for amendments, and whether such amendments can be accommodated by national courts on case-to-case basis.

1.3 Limitations of the study

This thesis will only cover the study of the international and domestic regulations listed above and shall evaluate the main dispositions that are relevant for ship-to-ship collision liability. Therefore, any other rules will not be part of the scope of this thesis, such as environmental, safety and labor regulations, among others.

However, this thesis studies the concept of autonomous vessels and its levels of manning and autonomy. Additionally, some of the most important international projects in terms of updating the current legal framework for autonomous or unmanned vessels are also addressed (IMO, CMI).

2 Legal challenges with autonomous ships

2.1 What is an autonomous ship?

It is important to note that from both an international and domestic perspective, there is no clear definition of the term ship. Nevertheless, when picturing a ship, one of the elements that until now has been irremediably linked to it, is precisely the existence of a master and a crew as the operational and navigational element of such vessel.

The main difference between autonomous/unmanned vessels, and traditional vessels is the existence of the human element, as well as its location. Traditional or conventional ships are those where the essential actions of navigation of the ship are performed and assumed by the master and the crew, while being on board. Autonomous ships are the ones in which its navigation and operation relies on a series of systems
and software which have the capability of making decisions and performing actions without or with little human involvement, depending on its level of autonomy. These autonomous ships can therefore be manned or unmanned.

In December 2017, Bureau Veritas\textsuperscript{6} issued the Guidance Note NI 641 DT R00 E, for Autonomous Shipping\textsuperscript{7}. These guidelines aim to serve as soft law applicable to autonomous shipping in terms of functionality and reliability of automated systems, risk and technology assessment, safety and security conditions and regulations.

Rule 1.4.1 of these Guidelines establish the definition of autonomous ship as follows: “ship having the same capabilities as those of a smart ship and including autonomous systems capable of making decisions and performing actions with or without human in the loop. An autonomous ship may be manned with a reduced crew or unmanned with or without supervision”.

Therefore, it is important to understand the main difference between autonomous and unmanned vessels; autonomy refers to the ability of a ship to perform its operations with little or almost no involvement of human beings, whilst manning relates to the physical presence of the master and crew on board a ship.

In addition, we have remote-controlled or partly autonomous vessels, which are unmanned vessels where the master and crew are involved in the operation of the ship, but they perform their duties from an on-shore location. Due to the involvement of this human factor, they do not have full autonomy.

Based on these descriptions, we can classify ships into conventional, unmanned, autonomous and remotely operated vessels\textsuperscript{8}.

\textsuperscript{6} Bureau Veritas is a recognized world leader in testing, inspection and certification services (TIC) in the maritime industry.


\textsuperscript{8} See \url{http://www.bureauveritas.jp/news/pdf/641-NI_2017-12.pdf} (Last visited November 2018)
2.2 Levels of autonomy and manning

Defining the level of autonomy, automation and involvement of the crew or master is crucial when determining the level of risk or liability applicable to a certain type of ship in a specific moment of navigation.

Before analyzing the different regulations that may be applicable to autonomous shipping, it is important to distinguish the level of autonomy and manning in order to be able to determine the way that such circumstances will affect the vessel’s liability within ship-to-ship collisions.

First of all, it is important to mention that the level of autonomy or manning cannot be used as a static category with respect to a specific type of vessel. Due to the nature of the technology and automation of these vessels, it is possible to encounter different types of autonomy and manning within one voyage. Therefore, it is necessary to have a clear understanding of the different levels of manning and autonomy and of their interaction within a same moment of navigation of a ship.

On one side, the level of manning of a ship relies on the presence of the master and crew on board of the vessel, regardless its level of autonomy. The levels of manning can be divided as manned, unmanned or periodically unmanned. Fully manned operations describe the navigation where a master and a full crew is on board to perform whole or part of their duties. Periodically unmanned operations refer to the type of navigation where the crew may leave the bridge unmanned under certain specific conditions (primarily during simple operations or sea passage\(^9\)). Finally, unmanned operations refer to the autonomous navigation where no master or crew is required on board of the vessel.

With respect to the levels of autonomy, Lloyds Register issued in 2016\(^{10}\) a Procedure Guidance that defined six levels of autonomy of ships that followed the same concepts

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\(^{10}\) Lloyd Register, July 2016- Ship Right Procedure Guidance- Autonomous Ships
set forth under the Definitions for Autonomous Merchant Ships, issued by the NFAS\textsuperscript{11} (regulations which are also based and relied on concepts developed previously for road vehicles) by describing such autonomy levels in a range from AL 1 to AL 6\textsuperscript{12}, as follows:

\begin{table}[h]
\centering
\begin{tabular}{|l|}
\hline
\textbf{AL 0)} Manual – no autonomous function. \\
All action and decision making is performed manually – i.e. a human controls all actions at the ship level. \textit{Note:} systems on board may have a level of autonomy, with ‘human in the loop’; for example, pms and engine control. Straight readouts, for example, gauge readings, wind direction and sea current, are not considered to be decision support. \\
\hline
\textbf{AL 1)} On-ship decision support \\
All actions at the ship level are taken by a human operator, but a decision support tool can present options or otherwise influence the actions chosen, for example DP Capability plots and route planning. \\
\hline
\textbf{AL 2)} On and off-ship decision support \\
All actions at the ship level taken by human operator on board the vessel, but decision support tool can present options or otherwise influence the actions chosen. Data may be provided by systems on or off the ship, for example DP capability plots, OEM configuration recommendations, weather routing. \\
\hline
\textbf{AL 3)} ’Active’ human in the loop \\
Decisions and actions at the ship level are performed autonomously with human supervision. High-impact decisions are implemented in a way to give human operators the opportunity to intercede and over-ride them. Data may be provided by systems on or off the ship. \\
\hline
\textbf{AL 4)} Human on the loop – operator/supervisory \\
Decisions and actions are performed autonomously with human supervision. High impact decisions are implemented in a way to give human operators the opportunity to intercede and over-ride them. \\
\hline
\textbf{AL 5)} Fully autonomous \\
Unsupervised or rarely supervised operation where decisions are made and actioned by the system, i.e. impact is at the total ship level. \\
\hline
\textbf{AL 6)} Fully autonomous \\
Unsupervised operation where decisions are made and actioned by the system, i.e. impact is at the total ship level. \\
\hline
\end{tabular}
\caption{Table 1.}
\end{table}

\subsection*{2.3 Sliding scale of manning and autonomy}

As mentioned above, within a single voyage different scenarios can be encountered involving specific levels of autonomy and manning, such levels will change depending on the circumstances and environment in which the ship is navigating at a certain point. These distinctions and specific considerations will change the legal approach of a particular vessel.

\textsuperscript{11} See \url{http://nfas.autonomous-ship.org/resources/autonom-defs.pdf} (Last visited November 2018).

\textsuperscript{12} AL stands for autonomy levels
This is precisely the reason for which many researches and other experimented authorities agree that determining the range of autonomy and manning of a specific ship is an important factor to assess liability, given that such situations could lead to differences in the legal consequences in case of a ship-to-ship collision, as discussed later in this paper.

For the purpose of simplicity when explaining this important aspect of autonomous shipping, Prof. Henrik Ringbom\textsuperscript{13} has developed a horizontal axis that foresees the range of combinations we can have in a single vessel with respect to autonomy of functions and manning. This axis is reproduced in this thesis for the purpose of analyzing the current and existing legislation.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Fig1}
\caption{Figure 1}
\end{figure}

Figure 1 represents not only the type of vessel (autonomous/unmanned) as a simple term to be analyzed, but furthermore, it represents the level of manning or automation that a certain ship may have \textit{during a specific navigation moment} under the same voyage. Its main purpose is to illustrate that, as studied before, manning and autonomy are different and have different levels which can coexist on a sliding scale.

For instance, if we consider the Yara Birkeland ship, it is possible to affirm that in a certain moment of navigation (e.g. mooring in port) she will be programmed to operate with constrained autonomy instead of operating with full autonomy as the external circumstances can be regarded to have a higher degree of complexity; while she may be programmed to navigate with full autonomy during sea passage, as the external circumstances can be deemed to involve less risks.

Additionally, under more complicated circumstances, the vessel may be programmed to have constrained autonomy and to be supervised by a mixed crew of personnel on board and other personnel located on-shore. In this complex, but highly possible scenario, we will have a fully autonomous vessel that in a certain moment of navigation should be analyzed under the rules applicable to partially unmanned vessels and with remote-controlled autonomy.

This sliding axis sets the parameters of the different scenarios when analyzing the legislation applicable for ship to ship collision liability in the next chapter.

3 Are autonomous ships allowed within the current international framework?

3.1 Current projects related to regulatory challenges of autonomous ships

Some international entities are currently working on the development of suggestions or drafts as to how maritime law might be amended to reflect the operation of autonomous and unmanned vessels\(^{14}\). The biggest efforts from an international perspective have been performed by the IMO and the CMI.

In March 2017, CMI through its Unmanned Ships working group, developed a national questionnaire to be responded by its members from all around the world. This questionnaire was focused on the current domestic and international applicable legislation with the purpose of drawing the bases for a deeper study on how these national

dispositions would limit or prevent the introduction or developing of unmanned or autonomous vessels, from a legal perspective.

In February 2018 22 countries submitted their responses to the CMI Working Group, which allowed CMI to develop a Summary of Responses as well as a position paper on the work that needs to be done in order to “prepare the legal framework for the safe operations of such ships”\(^\text{15}\).

In addition, the most important discussions and developments with respect to technical rules of navigation applied to autonomous or unmanned vessels are being made within the International Maritime Organization\(^\text{16}\), the purpose is to agree on a specific framework and tackle “possible gaps between current regulations and technological development”\(^\text{17}\). It is expected that the final results of this analytical work will be ready by 2020.

IMO as an international reference for the whole maritime shipping industry, has issued the most important international conventions and regulations with respect to health, security and environment practices from an international perspective\(^\text{18}\). It is important to note that none of these conventions or regulations include any disposition related to unmanned or autonomous vessels and therefore, it is expected that their rules may need to be adapted in order to be applied for this new technological development.

In early 2018, the Maritime Safety Committee of IMO (MSC) proposed an action plan for undertaking a regulatory exercise with the purpose of targeting required amendments to the existing framework of shipping industry in order to enable the operation of what they called “entirely or partly unmanned Maritime Autonomous Surface Ships (MASS)”. It is worth mentioning that this study has been mainly carried out by

\(^{15}\) See https://comitemaritime.org/work/unmanned-ships/ (Last visited April 2019).


\(^{17}\) See https://worldmaritimene\text{news.com/archives/253639/imo-moves-forward-to-address-autonomous-ships/ (Last visited February 2019).

\(^{18}\) Although IMO standards are also followed by its member states within their local regulations as an international standard.
Denmark, Estonia, Finland, Japan, the Netherlands, Norway, Republic of Korea, the United Kingdom and the United States.

As stated in the 99th session of the MSC in March 8, 2018\footnote{IMO (2018), MSC 99/5/n, Regulatory scoping exercise for the use of Maritime Autonomous Surface Ships (MASS).}, the proposed approach for this legal scoping exercise should be, first to identify the existing regulatory framework that may be applicable to autonomous vessels (or MASS), then target those dispositions that take into account the role of human element and that may arise problems within its application to MASS, this is, regulations that may eventually require some human presence on board in order to be fulfilled, and most important, establish equivalences or interpretations that will eventually allow the application of these rules to MASS.

Therefore, this specific study will follow the same targeting approach followed by the MSC of the IMO, but with a focus on ship-to-ship collision regulations.

\subsection*{3.2 UN Convention on Law of the Sea}

As a first point, it is necessary to start with the most important jurisdictional rules within maritime law, this is, the UNCLOS\footnote{Entered into force in November 1994.}.

The UNCLOS, also referred to as “The Constitution of the Oceans”, is one of the most important conventions ever signed. The convention is formed by XVII Parts and 9 annexes, each of which comprehensively regulates the most common jurisdictional problems related to, among others, navigation in domestic and international waters as well as the role that each of the coastal states, flag states, and the shipowners should perform during certain circumstances.

\subsubsection*{3.2.1 Article 90}

The first relevant aspect for the purpose of autonomous vessels in connection with the UNCLOS, is that, this international convention does not establish a definition for vessel...
or ship\textsuperscript{21}. This can be clearly appreciated within the wording of Article 90 of the UNCLOS: “\textit{Every State, whether coastal or land-locked, has the right to sail ships flying its flag on the high seas}”.

The wording of this article leads us to conclude that in general terms, the rules applicable in such convention for traditional vessels, can be equally applied for autonomous or unmanned vessels as there is no indication that the presence or intervention of a human factor is essential for the term ship\textsuperscript{22}. Moreover, each state has jurisdiction to determine the specific requirements that a vessel must comply to fly their flag. This allows them to complete, in case of doubt, the application of international rules to autonomous or unmanned vessels, through domestic rules.

So, as a starting point, the first conclusion is that unmanned or autonomous vessels can be considered as ships or vessels within the context of the UNCLOS. As stated in the Position Paper of the CMI, such terms can be used interchangeably between traditional and autonomous vessels without raising any additional challenges\textsuperscript{23}.

\textbf{3.2.2 Article 91}

Continuing with the dispositions of this convention, Article 91 states that “\textit{every state shall fix the conditions for the grant of its nationality to ships, for the registration of ships (…)\textsuperscript{24}}”, which means that the flag state has the right to register any class of ship and therefore, ships have navigation rights irrespective of the type of ship they are, as long as they are registered within a flag state.

As it can be seen, this disposition does not represent a challenge for autonomous or unmanned navigation as each one of the flag states is entitled to fix the conditions that vessels must meet in order to flag their flag and be under the scope of other international regulations.

\begin{flushleft}  
\textsuperscript{21} Article 1 and article 90 of the UNCLOS .
\end{flushleft}
It is to be expected that in the near future, countries such as Finland or Norway will start registering vessels with autonomous or unmanned features under their flags by issuing specific conditions for the grant of its nationality as the first prototypes and active projects regarding these type of vessels worldwide, are located in such countries.

3.2.3 Article 94

Furthermore, Article 94 of UNCLOS states the duties of the flag state, and foresees among others, the duty to take the measures that are necessary to ensure safety of the ships flagging its flag, specifically with respect to construction, equipment, seaworthiness, manning, labor conditions and training of crews, as well as to the maintenance of communication and the prevention of collisions.

With respect to that specific measure, the UNCLOS establishes that flag states shall verify that “each ship is in the charge of a master and officers who possess appropriate qualifications, in particular in seamanship, navigation, communications and marine engineering, and that the crew is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship; that the master, officers and, to the extent appropriate, the crew are fully conversant with and required to observe the applicable international regulations concerning the safety of life at sea, the prevention of collisions, the prevention, reduction and control of marine pollution, and the maintenance of communications by radio.”

As it can be appreciated from the above transcription, one of the most important features that is to be considered for the safety of a vessel and its proper navigation and administration, is the need of having a master, officers and a crew, all of them with special and appropriate qualifications and enough in quantity as per the size of the vessel.

It is important to note that article 94 is one of the most relevant provisions of UNCLOS and one of the most relevant duties for flag states and will eventually represent a challenge for autonomous or unmanned navigation. As mentioned in the previous chapter, autonomous and unmanned vessel do not typically require a master or crew, or they are not on board. Consequently, the question arises as to how the flag state verifies
that the staff is appropriate and have necessary qualification if such figures do not exist.

It is in this disposition where an interpretation problem may arise with respect to autonomous or unmanned navigation.

**Unmanned vessel with remote-controlled navigation**

How can a flag state comply to verify that a ship is properly manned and that her master and crew are adequately qualified and appropriate in number if there is no crew on board, and instead, we have different types of long distance teams located in a different location that may respond to the needs of the navigation in specific but diverse circumstances?

For example, we have an unmanned vessel which has partial autonomy. This is, the vessel is unmanned but there is a control room on shore (whether in the flag country or otherwise located) with a professional team that will supervise, and intervene, if needed on the navigation of the vessel.

It can be said that according with the classification of Lloyd’s Register this vessel is AL2, which means that some specific activities are performed through preprogrammed systems, but the human intervention on some other specific activities such as intervention in technical failure, overriding in dangerous situation, or similar, is possible and necessary.

In this specific case, the flag state duty foreseen under section 94 of the UNCLOS cannot be completely fulfilled with the way the current rules are drafted as a state cannot certify that a given vessel is properly manned and that its crew and master are well trained under the general practice standards that the maritime industry has had for more than 100 years.

However, broadly interpreted, it can also be said that the flag state may assert the proper manning of the vessel through other means, considering that the crew is not on board of the vessel and that such a rule does not specifically require that.
In such case, the flag state could verify the capabilities of the master, officers and crew that are going to be responsible for the vessel, while they are located in a different facility. Accordingly, it could be concluded that the location of the personnel in charge of the navigation and operation of the ship is of no relevance in order for the flag state to comply with the duty set forth under Article 94 of the UNCLOS.

**Fully autonomous navigation**

How can a flag state comply to verify that a ship is properly manned and that her master and crew are adequately qualified and appropriate in number if there is no crew at all, and instead, the ship is operated and navigated through autonomous systems and software that are able to make decisions and determine actions during the voyage with no intervention of human beings, not even located in a remote location?

In this specific case we are speaking of the most developed level of autonomy and unmanned vessels. It is to be expected that the duty of the flag state foreseen under article 94 of the UNCLOS cannot be fulfilled at all, due to the fact that it would be very difficult to adjust these rules and match the term “master, officer and crew” for a series of software and systems that are controlled by artificial intelligence and algorithms.

In the latter situation, the flag state would have a problem with respect to their duty set forth under article 94 of UNCLOS regarding an autonomous vessel.

However, it is important to remember that the task of UNCLOS is to set out the most important principles for maritime law, this is, applying principles rather than specific rules, in a way that such principles are valid through time and are able to endure changes in the industry, adapting themselves to new realities with the help of specific standards issued by “the competent organizations”, for example, IMO.

Under article 94(5) it is stated that “each State is required to conform to generally accepted international regulations, procedures and practices (…) to secure their observance”. The aforementioned means that the States can and must rely on generally accepted international regulations (this can be interpreted to be IMO Regulations) in
order to secure the specific compliance of the general dispositions set forth under the UNCLOS.

That means that IMO Regulations or other generally accepted international legal bodies should underline and develop the specific rules and procedures that are necessary so that States can comply with their duties, such as the ones analyzed in the previous paragraphs.

Consequently, according with article 94(5), this exact same view can be adopted for the purpose of applying the current existing rules set forth under UNCLOS to new forms of navigations such as autonomous or unmanned vessels through such generally accepted international regulations. With this in mind, some of the dispositions contained under the UNCLOS and other Conventions will need to be subject to broader interpretation and application by the member states in order to include autonomous or unmanned vessels to their scope.

It is of the opinion of the author that, probably, the best way to do so, will be through the issuance of international rules and standards that can help interpret conventions for the case of autonomous or unmanned vessels. The issuance of this rules could be done by the competent international organization (IMO, in this case). This way the introduction of new technological shipping development will occur in a smooth and easy way, preventing the need of amending all international conventions, which would result in a difficult and extensive effort of getting all parties\textsuperscript{24} to agree on the same topic.

Therefore, with the introduction of new legal rules issued by the IMO to help interpret all conventions or regulations and apply them to autonomous vessels, it is possible for flag states to validate and ensure the safety of the vessel through other equivalent measures such as the crew and master being on shore in a specific facility with emergency plans in place (in the case of remote control operation), or that the navigation

\textsuperscript{24} This is very important to mention, as UNCLOS is one of the most important conventions worldwide due to its high level of acceptance among states. Currently, the UNCLOS has 168 contracting parties.
done entirely through a software system is always updated and under the constant supervision of the shipowner.

3.3 **International Regulations for Preventing Collisions at Sea**

The COLREGs are the International Regulations for Preventing Collisions at Sea adopted by the IMO in 1972 and in force since 1977. The main purpose of this set of rules is to establish general rules for navigation and traffic at sea, preventing collisions and alerting of dangerous situations. These are also called the Rules of the Road.

COLREGs has five sets of rules (Part A-Part E) and 4 annexes. Part A refers to general rules 1 to 3 and mainly refer to the scope of application of these rules, as well as the responsibility of master and crew. Part B refers to certain specific rules regarding navigation (steering and sailing) contained under rules 4-19.

In connection with the scope of application of this set of rules, it is important to mention that COLREGs are applicable to vessel navigation through the high seas or waters beyond the national jurisdiction of a coastal state according with UNCLOS.

3.3.1 **Rule 2- Fault within collisions**

Rule 2 of the COLREGs foresees one of the basic and most important principles of navigation: responsibility. This disposition states that the neglect act of complying with COLREGs or with any precaution required according to the ordinary practice of seamen, will translate in the responsibility of the owner, master or crew.

The abovementioned term “ordinary practice of seamen” is a term that is ordinarily found in maritime law practice and underlies a subjective connotation that is difficult to understand under situations of remote-operated or autonomous navigation.

For most practitioners of maritime law, “ordinary practice of seamen” or “good seamanship” refers to common sense followed by maritime experience and knowledge in navigation. This term is included within the COLREGs as it is impossible for such rules to foresee all collision situations and therefore, applying this measure enables the
competent authorities to distinguish fault and responsibility on a case by case analysis, considering the specific circumstances of a given situation.

In this rule we find the first challenge with respect to the application of COLREGs to autonomous or unmanned vessels. This arises with the fact that it might appear illogical to determine if “good seamanship”, or “ordinary practice of seamen” was employed during a navigation performed by an automated computer software with precise instructions of what to do in specific situations and without the involvement of any human being.

**Unmanned vessel with remote-controlled navigation**

When speaking about remote-controlled operations, the situation is not so complicated, as in this case it is the master or personnel located on-shore the ones that operate the vessel and other equipment inside the ship according to their experience and standards of good seamanship, and therefore, this same rule is applicable without any further complication, regardless of the location of the crew, master or any other personnel for whom the owner is liable.

In such case, in order to determine the fault of one party within a collision, one must prove that such party’s personnel located on-shore (or in any other remote location) did not comply with one or more of the safety dispositions foreseen under COLREGs or with any precaution required according to the ordinary practice of seamen, representing a liability for the shipowner within a collision.

However, it should be understood that the COLREGs as they are written today will need to have a broader scope for specific details or conducts foreseen therein in order to be standardized for both autonomous and traditional ships, as it will be studied further on. For example, the introduction of new technologies or equipment that did not exist before.

**Fully autonomous navigation**
In the case of vessels with a high level of automation, where navigation is performed by specific computer software without or with occasional direct human intervention, the application of Rule 2 would appear to be more complex in terms of determining fault. This consideration should be applied to navigation from level AL 4 and through level AL6\textsuperscript{25}, as the main obligations within navigation in those situations are performed through a computer and the decision duties for the human factor are merely focused on supervision or are rarely required and it is difficult to consider under the current rules that a computer program can have the precaution required according to the ordinary practice of seamen according to such COLREGs. In such a case the term “ordinary practice of seamen”, would be difficult to equate to a fully autonomous vessel and its systems.

For example, we have a ship with an AL4 level of autonomy (according to Lloyd’s Register classification), this means that all decisions and actions during navigation are performed autonomously, only with human supervision, allowing this human factor to intervene and override certain instructions in case of risk or danger.

According to Rule 2 of the COLREGs, in case the human factor operating such a vessel neglects to have the corresponding precautions -or does not override the system when a risk arises- such actions can be translated in responsibility, if the human factor did not act according to ordinary practice of seamen. In conclusion, there is room for interpretation and application of Rule 2 in this specific example.

However, if instead of having an AL4 ship we have an AL6 (fully autonomous ship), the application of Rule 2 would be more complex. For AL6 vessels, the navigation and operations are unsupervised, and the decisions are actioned by a system without human intervention. Consequently, how can a preprogrammed computer comply with ordinary practice of seamen?

\textsuperscript{25} This consideration is based on the Lloyd’s Register classification of autonomy, and given that the navigation duties for the human factor end in AL2 and AL3 only foresees a supervision duty.
For all of the above, it can be concluded that this rule of the COLREGs will need to be adapted so that the human judgement that comes from the practice of good seamanship can be complied with a variation for autonomous vessels.

3.3.2 Rule 5- Duty of Lookout

One of the safety duties that the master and/or crew must comply in order to navigate with duty and good seamanship is established in Rule 5 of the COLREGs. The duty of lookout means, in general terms, that a permanent watch shall be kept from the bridge of the vessel in order to be aware of the sailing conditions and to assess risky situations involving other vessels or external circumstances.

In this specific case, the legal issue arising from the application of this rule to unmanned or autonomous ships is not so complex. This is due to the previous evolution that this disposition had. At first, this rule stated that the lookout should be done by having a proper watch and hearing of the external circumstances of the ship, this is, the officer on watch should go to the bridge and see and listen for all of what was surrounding the vessel.

However, due to the later modernization and change in the design of the bridges it was usual that the bridge was covered and therefore, the hearing was now not possible, and the visibility was also reduced.

As a consequence, thereof, it is now stated under Rule 5 that the lookout should be performed using all the available means such as technological tools or equipment that can help to assess a given situation in both hearing and seeing\(^{26}\), for example, radars for interferences and traffic.

Therefore, when speaking about traditional or autonomous vessels, this rule can apply in the same direct and objective way. In both cases, the lookout can be done through smart equipment or tools as long as they are able to detect any object that crosses the path of the vessel with the purpose of avoiding any collision.

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As mentioned above, COLREGs have already adopted a technological neutral term for complying with this lookout duty by allowing the use of all available means, this is, all the systems, accessories or technological appliances that allows to know the circumstances that surround the vessel for the purpose of avoiding a collision.

3.3.3 Rules 7 and 8- Risk and action to avoid collision

Rules 7 and 8 of the COLREGs regulate risk of collision and action to avoid collision. Both rules rely on the fact that that all circumstances and conditions of the vessel are to be evaluated in order to determine if collision risks exist and, in such case, take any and all positive actions to avoid said risks and avoid collision.

These rules, rely on the fact that whoever is in charge of navigating the vessel (it is not specific in establishing the term master or crew), shall use all available means to determine if a risk of collision exists (again, without being specific on the means that should be used). When the risk is deemed to exist, actions to avoid the collision must be taken, such as alter the course of the vessel or reduce speed in a way it is apparent to the other vessel, among others. As it can be appreciated, the application of these specific rules for both traditional or autonomous vessel would not represent a big challenge, and as such, rules are written in a general and technologically neutral way that allows the possibility that a software or system is the one that is programmed with specific instructions for reacting in a certain way in case a risk is detected.

3.3.4 Applicability of COLREGs to autonomous vessels

As a general conclusion with respect to COLREGs, it can be said that although these regulations do not foresee the existence of autonomous or unmanned vessels as such, their rules could accept its application to this type of vessels. Notwithstanding the above, in order to have a framework specifically designed for the navigation of unmanned and autonomous vessels, it would be necessary to develop written rules in this respect and that can be deemed as international generally accepted rules\footnote{Considering the disposition foreseen under article 94(5) of the UNCLOS.} with the purpose of stating the equivalence of terms and rules in COLREGs for autonomous vessels.
and unmanned vessels, referring to their level of autonomy while navigating. Thus, ideally these rules would be issued by the IMO. The issuance of this independent and specialized rules would simplify the application and interpretation of the existing rules and legal background.

As it can be appreciated from the above, the interpretation of COLREGs is just an example of the legal situations that may arise from the application of traditional rules to unmanned shipping.

However, as mentioned in the previous paragraph, and following the opinion issued by CMI, the author appreciates that it would be enough to make clarifications and issue interpretation rules in a separate document presented ideally by the IMO, introducing new parameters that will make these rules compatible with the new technological advances and special requirements of autonomous and unmanned navigation.

For the case that IMO issues a document in 2020 that underlines the specific rules for autonomous navigation within COLREGs, it could, for example, be read as follows:

“For Rule 5- Duty of Lookout, “the relevant sight and hearing may be provided by shore-based personnel through use of cameras and sound receptacles” (or any other device or program). Therefore, the term “sight and seeing” within this rule does not require a direct human perception. Additionally, this requirement should be deemed satisfy by the response performed by a vessel during fully autonomous navigation in terms of sight and seeing that is based on the information provided by “sight and seeing devices or programs” and then processed by algorithmic collision avoidance technology28.

As seen in the previous example based on Rule 5, in this way the COLREGs will remain untouched but their application scope will be extended to other types of navigation that go beyond traditional shipping without altering the previous consensus that was reached by the signing countries of this rules.

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Additionally, it is important to mention that the fact that these rules are issued by the IMO allows their adoption and implementation to be easier as currently 174 countries are members of this organization.

3.4 The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

The introduction of autonomous vessels will also change the paradigm within regulations for seafarers, manning and crew training. One of the most relevant Conventions in this respect is the STCW.\(^{29}\)

Article III of the Convention states that the STCW shall apply to all seafarers “serving on board sea-going ships”. This means that no application can be interpreted or foreseen for those seafarers that work for an unmanned or autonomous vessel, i.e. onshore-based seafarers.

More importantly, Chapter VIII—Watchkeeping, establishes a series of rules for Administrations in order to prevent fatigue of the seafarers and to ensure that all watchkeeping personnel comply with the guidance and requirements set under the STCW Code in order to ensure safe and continuous watches at all times. These rules ensure that the master of the vessel is aware of any and all circumstances surrounding the ship that may lead to a risk of collision.

It is obvious that in the case of autonomous or unmanned vessels the rules set forth under Chapter VIII are not applicable as they are not compatible with the new technological background surrounding an autonomous ship or to the location of the master and crew for the case of unmanned vessels.

Consequently, a new regime is needed for remote controllers and other personnel that are in charge of an unmanned vessel and for other specific personnel (such as preprogrammers) in case of autonomous vessels. The requirements that are currently stated under the STCW can be used as a basis for defining the qualification and duties.

of the personnel. Particularly, the responsibilities of watchkeeping should be adjusted taking into consideration that the watchkeepers could be on shore or that these functions can be performed automatically through software or other equipment. As it can be seen, there is an important problem arising from the current wording of the STCW, as all of these rules are only applicable to seafarers serving on board a ship.

Regarding, the new category of seafarers working under remote-controlled operations and thus in control of avoiding risk or collision, should these on-shore personnel not also comply with the rules set forth under the STCW?

Therefore, it can be concluded that the legal loophole that arises from the application of Section VIII to unmanned and autonomous vessels shall be completed and amended by each one of the state parties to this Convention.

At international level, the answers to many of the questions that have been analyzed herein are far from being clear. However, most of them are being addressed and developed by the Maritime Safety Committee of the IMO with the purpose of delivering a report in 2020 that makes it possible to bring international solutions to enable the safe navigation of MASS.

However, by the time such report is issued in 2020, the maritime countries should be ready to amend or accept any proposals that are addressed by the IMO, especially those that will, by that time, already have navigation of unmanned or autonomous vessels within their jurisdiction, such as Norway.

4 Liability for collisions

4.1 General overview

From the analysis made under the previous chapter of this thesis, it can be concluded that the most important jurisdictional, technical and safety regulations that are part of the maritime legal framework do not foresee or contemplate the specific features of autonomous or unmanned vessels. However, although the introduction of this type of ships to the maritime transport industry will raise some legal concerns, unmanned and
autonomous ships are allowed under the current framework and the obstacles for the appropriate application and interpretation of the current regulations should be tackled through amendments, clarifications or issuance of new rules, as explained above.

Now that the lawfulness of these vessels has been generally addressed, the paper focuses on the subject of this study: liability rules in a ship-to-ship collision. It is important to note that the purpose of this thesis is to study and analyze the most relevant liability dispositions as well as the legal consequences that will arise when applying them to autonomous and unmanned vessels.

As it has already been explained, the technical features of this type of ships are not definitive and unique, but they tend to move from a wide range of autonomy and manning levels that lead to different issues and legal implications. Therefore, this section will focus on explaining the different implications of applying specific liability rules on ship to ship collision, considering different levels of manning and autonomy.

As a first point the Convention for the Unification of Certain Rules of Law with Respect to Collisions (1910) will be analyzed, in connection with the Norwegian Maritime Code and considering specific case law relevant for each one of the cases.

4.2 Convention for the Unification of Certain Rules of Law with Respect to Collisions

The Convention for the Unification of Certain Rules of Law with respect to Collisions (or the 1910 Brussels Convention) was issued in September 1910 as an effort to regulate collisions that occur between sea-going vessels and/or vessels of inland navigation in whatever waters. So far, 88 countries have executed or ratified this multilateral instrument and Norway is an example of a country that has adopted these international dispositions within its domestic legislation, as discussed later in the present work.

This convention follows the fault-based principle of liability for collisions, which means that the collided party has to prove there was a breach in the compliance of a duty of

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care of the colliding party in order to allocate liability. So, if either the shipowner, or any other person for whom he or she is responsible for, is to be blamed for the collision, the shipowner will assume the damages caused by such event. Additionally, proportionality of fault and accidental collisions are also foreseen under such convention.\(^{31}\)

Through the text of the 17 articles of this Convention\(^ {32}\), it is said that the liability arising from the collision of two vessels will be allocated on the one that committed a fault. Then, the liable person in case of collisions according with this Convention is the shipowner or someone he or she is variously liable for, when one of them had *culpa* in the accident.

Likewise, it is foreseen that for the case that two or more vessels are in fault, each of them will be liable in proportion to the degree of the fault they committed, considering that it is very difficult to find cases of collisions in which there was just one fault that lead to the collision to occur, and most of the times a series of complicated events and factors contribute to the causation of damage. This is called shared liability.

As seen, the evaluation of fault is of the utmost relevance in order to determine the existence and degree of fault when speaking of ship-to-ship collisions. An example of this can be seen in the Norwegian Case ND-1983-343, where a pleasure craft collided with a fishing vessel. In this case the Norwegian courts determined that the fishing vessel was navigating at a high speed in a dark area with no anchor lights, while the pleasure craft was not aware of the risk on time due to the lack of a proper lookout. It was determined that both ships were to blame for the collision in a 50/50 proportion.\(^ {33}\)

As seen from the previous case the courts have the obligation to consider and analyze all the circumstances surrounding the accident in order to determine the causes of it in order to allocate fault. It is important to note that in order to evaluate a fault within ship to ship collisions, the principle of proximity of the cause or *causa proxima* can be applied by courts in order to achieve an assessment of circumstances based on


\(^{33}\) See Case ND-1983-343 (Fritidsbåt – kutter)
reasonableness and that entails a fair apportionment of the fault between two colliding ships. A proximate cause is not the first, or the last or the sole cause of the loss; it is the dominant or effective or operative cause.\footnote{Attard, D. J., Fitzmaurice, M., A., M. G., Arroyo, I., & Belja, E. (2016). *The IMLI manual on international maritime law*. Oxford, United Kingdom: Oxford University Press, p. 510}

Additionally, Article 2 of the Convention states that if the collision was caused by force majeure -technical failure- or no one is to be blamed, the damages are borne by those who suffered them.

It is also relevant to mention that Article 6 of this Convention states that “all legal presumptions of fault in regard to liability for collision are abolished”, and therefore it is understood that no strict liability or specific burden of proof can or shall be allocated to any of the colliding parties.

As it can be appreciated from the aforementioned, the fault-based liability system foreseen under the 1910 Brussels Convention rests on the existence of a breach from one of the colliding parties with respect to a duty of care foreseen under any legal or technical provision (statutory disposition)\footnote{Mandaraka-Sheppard, A. (2013). *Modern maritime law*. Abingdon, Oxon: Routledge}.

This Convention requires the adoption of the signing countries within their domestic legislation, so it is more probable that any problem arising from its application to autonomous navigation will have to be addressed within the national jurisdiction of each one of the adopting countries, as it will be studied in the following chapter.

### 4.3 Norwegian Maritime Code

In terms of legal framework, Norway’s shipping activities are regulated under NMC which latest version was issued in 1994. Chapter 8 of the NMC was adopted in the same terms as the Brussels Convention of 1910 and therefore liability arising from ship-to-ship collisions is founded also in a fault-based liability system\footnote{Wahlgren, P. (2004). *Maritime & transport law*. Stockholm: Stockholm Institute for Scandinavian Law.}. However, it is also possible to apply the general principles set forth under the Norwegian tort law\footnote{Falkanger, op cit p.140}. 

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37 Falkanger, op cit p.140
As per Chapter 8 of the NMC, there are three general rules when speaking of collisions that lead to different results in terms of liability. The first one is a collision where there is one colliding party to be blamed, the second is a collision where both of the parties are to be blamed, and the third one is an accidental collision, this is, where none of the parties are to be blamed.

4.3.1 Collision resulting from fault on one or both sides and accidental collision

Section 161 of the NMC\(^\text{38}\) regulates the collision of ships resulting from the fault of one or both sides, that is, the first and two scenarios mentioned above. The damages caused by such collision, include material damages to other ships, goods, or other structures, as well as personal injuries or death caused to persons.

In case the fault can be allocated only on one side, then such colliding ship should cover any and all damages.

However, if there is fault on both sides, the value of the damages should be apportioned between the two colliding parties, considering the level of fault they had in a given incident. And if there is no possibility for the parties to determine such level, damages will be paid in a 50% - 50% proportion.

These provisions currently apply for traditional navigation, and in the following paragraphs their applicability under the different levels of autonomous and unmanned vessels is analyzed.

4.3.2 Unmanned vessel with remote-controlled navigation

Picture an unmanned vessel with most of her operations done at an on-shore center where people performing different navigation activities and supervision of the systems are located. While sailing under partial autonomy such vessel collides with a traditional ship. After an assessment of the accident it can be said that the main causes of the collision were:

\(^{38}\) Section 161 NMC
1) The people onshore, in charge of supervising and assessing the look-out equipment installed on the ship, failed to spot that there was a problem with the automated radar and its plotting aids, and therefore they were not able to intervene the system and react until it was too late. As a consequence of the system failure, without reducing speed, the ship continued at a regular speed as no risks were detected by the automated system.

2) The collided vessel (traditional ship) was not navigating at a safe speed but reacted accordingly once the colliding vessel was spotted by her radar. However, such a colliding vessel was sailing at such a speed that the collision was inevitable.

Applying Section 161 of the NMC as it is written today, would lead us to conclude that both shipowners (through the actions of the crew and master) had a certain proportion of fault in this accident. The COLREGs, that were analyzed in the previous chapter will provide the standard of care and behavior required for navigation at sea. The colliding vessel through her personnel located on-shore breached Rule 5 and Rule 6 of COLREGs (duty of lookout and safe speed), while the master on board of the collided vessel breached Rule 6 of COLREGs (safe speed).

Therefore, the fault should be apportioned according to the circumstances of the case, which may give us grounds to affirm that the colliding vessel should be blamed for 90% of the fault, with the collided vessel blamed for 10% of it.

Although it may appear simple to conclude that the involvement of this remote controlled navigation of a ship is just transferring the duties and responsibilities of the crew to the onshore personnel, it must be also considered that the level of care that is expected from the shipowner and personnel of a remote controlled ship is higher and therefore a mistake or negligence act from the responsible personnel should give a different approach to the whole fault assessment.

The fact that an unmanned vessel with remote controlled navigation was involved in this case may bring a special perspective to the way the circumstances would be analyzed. For example, if this case was to be brought before a court and a proxima causa
approach was to be applied, the analysis of the specific circumstances of the collision may allow us to realize that the fault that lead to the accident that occurred is to be blamed 100% on the colliding vessel (remote-controlled vessel). This can be supported by the fact that a remote-controlled vessel should be subject to a higher degree of care and that the collided vessel reacted accordingly in order to prevent the collision. Furthermore, the fact that the collided vessel was not being navigated at a safe speed at the beginning of the incident had no relevance for the collision per se.

Therefore, the principal cause that lead to the collision was the fault of the lookout personnel of the colliding vessel, which had the duty of supervision of all the systems, and the possibility to override them in case of error. Consequently, the shipowner of the colliding vessel would be entirely liable for the accident.

Although courts will base their determinations and resolutions on applicable law, circumstances will play an important role during the evaluation of fault, and autonomous vessels should be required to have a higher degree of care when navigating in remote controlled navigation when assessing the collision. As seen, the factual circumstances and the level of care that should be allocated on the remote-controlled ship will in fact modify the whole outcome of application of the current rules foreseen under the NMC and the 1910 Brussels Convention.

Consequently, jurisdictional activity (as well as arbitration courts) will have an important role in the implementation of collision liability rules to autonomous ships, as the individual decisions that may be developed in the course of the next years will set the path for construing such rules under determined circumstances.

4.3.3 Fully autonomous navigation

In case of a fully autonomous vessel, this is, an AL6 according to Lloyd’s Register, in which no human intervention occurs, the situation appears to be more challenging from both, a legal and a factual perspective.

Picture a vessel sailing under a full autonomy level, she has no master or crew, and all her navigation duties are performed through automated systems and software which
interprets data obtained from the equipment installed on the vessel, and then, through a series of algorithms takes decisions accordingly. There is no human supervision nor possibility to override. While on sea passage and fully autonomous navigation, this vessel collides with another vessel (traditional navigation). After an assessment of the accident it can be said that the main causes of the collision were:

1) Technical fault on the colliding vessel. The causes are still uncertain, but it appears that all navigation systems failed, probably due to an unauthorized intervention of the vessel (cyberattack).

2) The collided vessel (traditional ship) complied with all rules for safety in navigation and her master and crew performed all the reasonable measures to avoid collision.

Applying Section 162 of the NMC as it is written today, would lead us to conclude that there is no fault from any of the shipowners (or their master, crew or personnel) as no standards of care or rules of behavior (such as COLREGs) were breached. As a consequence of the above, each ship should bear its own loss. This is based on the understanding that no human error or involvement can be deemed as a contributing factor in the collision according to the assessment performed under the light of the proximity principle, and if the supervision of the shipowner, master or crew to the ship was diligent enough to be able to detect or prevent such technical fault.

This view is aligned with diverse case law that has been issued regarding technical fault arising in collisions between ships. Marna Hepsø is one of the most relevant examples. In this case a technical situation occurred (splint in the gear linkage between the bridge and the engine room), which made it impossible for the master of the ship to engage the reverse gear, as a consequence thereof, the vessel collided with several ships that were moored. The court decided that no fault could be allocated to the shipowner, the master or the crew, as they complied their duty of care of supervising the correct state of the vessel at the moment of departure, consequently this accident was catalogued as unavoidable and none of the parties were to be blamed.

After arriving at this conclusion, it is clear that Section 162 as it is written today would raise an important precedent of unfairness when applying it to fully autonomous
vessels. How can you continue with a fault-based liability system in ship-to-ship collisions, when it is evident that the results of applying this system turns out in an unfair situation in terms of allocation of liability?

Liability for dangerous enterprise is a theory applicable for torts, which posits that certain businesses or activities should be subject to a strict liability regime for the damage they cause. According to Professor Mark Geistfeld in order to apply this theory the activity should be "abnormally dangerous" and its application will avoid the application of inefficient tort rules.39

After the result obtained by applying the current legislation -Section 162 of the NMC- and case law -Marna Hepsø- to the case described above, the author concludes that the most reliable and objective way to allocate liability in the case of AL6 ships where the collision was caused by a technical fault is switching from a fault-based liability system (as foreseen in the 1910 Brussels Convention) to a strict liability system.

With this modification, fully autonomous vessels shall be brought to a special liability regime -strict liability- where, in case there is no personal fault committed by none of the parties -accidental collision-, the shipowner of the autonomous vessel is objectively liable for the damages caused by the technical fault. This special liability regime should be only applicable to autonomous vessels with no manning level and a high level of autonomy -AL5 to AL6- where no human involvement is foreseen or required.

However, the discussion now focuses on the feasibility of adopting this new system of liability for highly autonomous vessels to the current statutory rules. As mentioned above, both Chapter 8 of the NMC and the 1910 Brussels Convention foresee a fault-based liability system for the case of ship-to-ship collisions, and therefore strict liability is left out of the picture. Furthermore, article 6 of the Convention states that all legal presumptions of fault in regard to liability for collisions are abolished, which means that no strict liability provisions can be stated within the domestic law to be compliant with the 1910 Convention.

In a strict liability regime for autonomous ships, the shipowner of the autonomous vessel will have a burden or legal presumption of fault against him/her with respect to the traditional ship, however, the shipowner of the autonomous vessel has the burden to prove one of two situations: a) that the traditional vessel had fault within the accident, in which case an assessment of the causes of the collision must be performed in order to determine the apportionment of liability, according to Section 161; or b) that the autonomous vessel, the shipowner and her technological elements complied with all duties of care required, in which case section 162 of the NMC could be applied the way it is now.

The result of this proposal is a reversed burden of proof, which means that the part which is subject to such strict liability will have the burden of proving that the technical fault, in this case, was not due to fault or negligence of the ship, her technological elements, the shipowner or any personnel related to her. Therefore, the burden of proof will be one of the most relevant aspects to balance this new strict liability imposed to the navigation of fully autonomous vessels as a form of dangerous enterprise.

We are therefore speaking of a strict liability system that involves a reverse burden of proof to the shipowner of the autonomous vessel and a higher degree of care imposed to the autonomous ship based on the fact that her special circumstances must be considered as a dangerous enterprise, which is not compliant with the dispositions set forth under Article 6 of the 1910 Brussels Convention.

The shift to a strict liability system is based on the abovementioned doctrine of dangerous enterprise and on the Norwegian Tort Act, complemented with the assessment of circumstances that must be performed in order to determine causes. With respect to the higher degree of care, based on the doctrine of dangerous enterprise, the case Bravur shows a clear example of how shipowners can face higher standards of care in order to guarantee the fairness and equilibrium between the parties involved in a certain collision\textsuperscript{40}. In such case -which will be studied further on- the shipowner was found

\footnotesize{\textsuperscript{40} ND 1995.163 DSC case}
to be liable for the collision due to his lack of inspection with respect to the faulty design on the ship’s pneumatic cylinder.

It is important to mention that there are a few cases in Nordic Law in which strict liability has been imposed in maritime law, but these have been only with respect to ship colliding with other structures. This court determinations -Neptun and Sokrates\(^{41}\)- follow the ordinary principles of Norwegian tort law\(^{42}\) with respect to collisions with other structures and determine a non-statutory strict liability to the colliding ship.

According to Falkanger and Bull, there are no special rules regulating collisions between ships and other structures under the NMC and the liability is allocated based on general tort rules -Norwegian Tort Act-. Therefore, the determination of imposing strict liability to the shipowners whose vessels collided with other structures such as docks or bridges, is based on non-statutory strict liability imposed by the courts.

Consequently, the author concludes that there is no need to amend the NMC with the purpose of adding new dispositions regarding autonomous vessels with a high level of autonomy in the collisions arising between such types of vessels and traditional ships, as the necessary adjustments can be made through non-statutory rules and case law. Although, a conflict with the 1910 Convention will arise.

Applying all of the abovementioned reasons and conclusions to the specific case described at the beginning of this chapter, it can be concluded that if an evaluation of causes and circumstances following the proximity of the cause principle lead us to confirm that the main cause of the collision was due to a problem in the navigation systems derived from the unauthorized intervention of the colliding ship by a cyberattack, although there was no fault committed by the shipowner; it can be concluded that the collision shall be blamed 100% to the colliding vessel.

However, in the case where the shipowner proves that the vessel was compliant with the cyber-risk assessment according to written rules for autonomous vessels, as the

\(^{41}\) ND 1921.401 NSC NEPTUN and ND 1952.320 NSC SOKRATES

\(^{42}\) Norwegian Tort Act of 1969
managing software of the ship had three or more levels of protection to prevent unauthorized access, then it should be deemed that the shipowner complied with a higher degree of care -as in the Bravur case- and such collision may be treated according to Section 162 of the MC, and each ship should bear their own costs.

4.3.4 Collision between two autonomous vessels

Collisions between two autonomous vessels in a fully autonomous navigation will not raise any specific questions with regard to the system of liability that they should be subject to, as they are both in the same circumstances, and as no special equilibrium has to be pursued, both of them will be subject to a fault-based liability system, or in case no one is to be blamed -because of technological causes- then each ship will bear its own lost, as stated under Section 162.

4.3.5 Vicarious liability and IT developers

The fault-based liability regime set forth under Chapter 8 of the NMC and the 1910 Convention, is directed to the behavior and actions of the shipowner himself and of the master, crew, pilot, tug or others performing work in the service of the ship. Therefore, this situation is specifically relevant when speaking of unmanned vessels or autonomous vessels in which no involvement from a human being is required.

The main conditions that must be proven is the existence of the damage of one or both ships as a consequence of the contact between them. If it was caused by the fault or negligence of a helper, then the shipowner will be liable. It is important to mention that only a breach of duty of care that is causative to the damage can make the shipowner liable for the collision.

Therefore, vicarious liability for the reder applies in collision situations considering the same parameters to assess if there is fault as the ones established under the Rules of the Road (COLREGs). Consequently, the fault or negligence committed by a

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43 Section 151 NMC
45 Pursuant to the definition set forth in the preface of the NMC
person for who the shipowner is liable is considered to be the cause of liability for the owner in case of a collision.

However, different parameters and criteria should be considered when allocating fault and liability when speaking on vicarious liability. This, as there will be some cases in which the terms set forth under section 151 to determine vicarious liability will not be clear enough when speaking about unmanned or remote-control vessels (when the negligence comes from the actions of a person performing work in the service of the vessel). For example, what if an autonomous vessel is being bareboat chartered and it collides due to fault on the navigation software developed and owned by the shipowner? Who would be liable then, the bareboat charterer or the shipowner?

Moreover, the introduction of new software and hardware enabling autonomous navigation of vessels is bound to cause new legal issues. For instance, will software suppliers accept the risk of becoming liable for a collision caused by a flaw in the system or algorithms developed by them? Must the reder also be liable for faults in the programming or software developed by a third-party? Should this party be considered as a person performing work in the service of the ship according to section 151 of the NMC?

According to Selvig, case law from recent years shows that the shipowner is liable for independent contractors as long as they perform a work in the service of the ship\textsuperscript{46}, an important aspect to consider is that a reder will be vicariously liable if he had the right to supervise performance, give instructions, and check the quality of the product or work performed by the party rendering a service to the ship.

However, the nature of the works is of great relevance to determine vicarious liability of the reder. If the work or service done to the ship is not a typical activity which, under normal circumstances, the reder should be performing, then it would not result in a liability for the shipowner. For example, in ND 1979.1-NCA MYREVÆRING and DRIFTIG, the reverse gear in a new ship overheated, as a consequence of a faulty

installation of such gear. The vessel collided with other vessels and the court attributed the fault to such technical defect, however as no fault was on the side of the shipowner and the shipyard is usually not under the scope of vicarious liability, such yard was found liable\textsuperscript{47}.

It is to be understood then, that the developers in an autonomous vessel will construct and architect all the algorithms, instructions and interfaces required to interconnect all the systems, mechanisms and technological equipment in a ship, which will perform regular navigating activities such as speed, radar, fueling, among others. Although they are an independent contractor, they are performing activities in the service of a ship, activities that would traditionally be on charge of the shipowner, master and crew, and therefore, it is of the opinion of the author that the shipowner would be vicariously liable in case of a collision.

Nevertheless, pursuant the Norwegian law on product liability\textsuperscript{48} the shipowner would be entitled to share liability with such developer by means of a recourse action, in the proportion such defective product was the cause of the collision and within certain specific limits -such as the value of the contract-\textsuperscript{49}, this situation however, is not part of the scope of this work and therefore will not be studied in more depth.

\section*{4.4 Norwegian Case Law}

As mentioned in this study, one of the possibilities to adapt the current legal system and rules from traditional navigation to autonomous or unmanned navigation is through non-statutory rules and the establishment of case law in the different countries where those technological advances are to be implemented in the short term.

Specifically, from the Norwegian Maritime Law perspective both international and domestic regulations are leaving many loopholes for the application of statutory rules,

\begin{itemize}
\item \textsuperscript{47} Falkanger op cit P.207
\item \textsuperscript{48} See https://www.raeder.no/globalassets/var-kompetanse/fagomrade/forsikring-og-erstatning/pl16_chapter-23_norway.pdf (Last accessed April 23, 2019)
\item \textsuperscript{49} See 85/374/EEC Directive
\end{itemize}
and it is case by case with the help of the judges, where those loopholes can be closed and those case law can serve as a base to start developing new rules.

This work also aims to analyze some of the most relevant Norwegian cases in terms of collisions that may either help the interpretation or application of the current legal principles to unmanned vessels or that are drafted in such a way that will raise challenges when they are applied to this new type of navigation. In this respect, we can recall the following cases, in which the Norwegian Supreme Court or other Scandinavian courts perform an interpretation of the dispositions set forth under the NMC with respect to collisions, and that nowadays represent a way to apply law.

- **Marna Hepsø (ND 1971.36)**

In this particular case, fault is analyzed under the light of a technical fault as the cause of the collision. The Supreme Court of Norway determined that when no negligence or fault is to be allocated within the colliding ship, then both ships have to bear their own damages caused as a result of the collision.

As it can be appreciated, section 162 of the NMC was interpreted in this case and it was decided that when the cause of the collision is a technical fault in the colliding ship, then it will be considered a “no one to blame situation” and therefore, each ship will cover their costs.

However, this resolution cannot be used as an interpretation guideline for the case of autonomous or unmanned vessels. When speaking for instance of a fully autonomous vessel, it is obvious that any and all faults and flaws within navigation of such vessel will be considered to be technical faults -as no human intervention is done- and the autonomous vessel will never have fault with respect to a traditional vessel within this Marna Hepsø interpretation.

Therefore, as mentioned above, in this respect a very detailed analysis of the circumstances and the imposition of a higher duty of care and a reversed burden of proof should be imposed on the shipowner of the autonomous vessel in order to have equilibrium within the involved parties of a given collision.
• Bravur (ND 1995.163 DSC)

In this particular case the ship collided with the jetty as a result of a manufacturing issue with the design of the pneumatic cylinder. However, both the first instance court and the appealing court decided that liability should be imposed to the shipowner, defined by the first court as “virtually strict liability”\(^\text{50}\).

This Bravur case is more applicable when speaking of allocation of liability due to collision within automated ships. Such case law has allowed the application of a strict-liability system under very specific circumstances as an exception to the general rule set forth under the MC, which can be useful when speaking of autonomous vessels. Consequently, as it can be seen, specific circumstances which are not clearly developed or defined within the NMC have been covered by case law.

Therefore, it is considered that this type of interpretation would suit to accommodate the current domestic rules for the collisions occurred by an automated or unmanned vessel, considering the specific circumstances on each case and more cases will be developed with time as the navigation of autonomous vessels start in Norway. However, as it was mentioned in the previous chapter, Norway is one of the signing countries to the 1910 Brussels Convention and as such, switching to a strict liability system for autonomous vessels will impact on the spirit of such convention.

• ND- 1979.1 NCA DRIFTING and ND 1977.128 NCC HAVSTEIN

These cases are specifically relevant with respect to the burden of proof given to the parties associated to a collision. They are related to technical failures (reversing machinery and reverse engine) due to improper installation and poor maintenance. However, the court found that the tortfeasor did not provide sufficient element to prove that the collision was not under the direct consequence of its fault or negligence, and therefore they imposed liability based on Section 161 of the NMC.

\(^{50}\) Falkanger op cit. p.283.
These precedents show the importance of the element of proof in order to allocate liability. For the case of autonomous vessels, if we consider that non-statutory rules will impose a reversed burden of proof subject to a higher degree of care, the proactive action of the shipowner is a decisive factor in allocating liability.

5 Conclusions

With technological advances, reality is always a step ahead of law and regulations. This is why lawyers and policymakers have to take an active role in developing adaptable rules that can satisfy the new needs, but still protecting the safety of navigation and ensuring the coordination and cooperation between countries as well as between the most relevant actors within the industry.

After a whole and specific analysis of the current conventions, rules, laws and case law in terms of collisions and liability for autonomous and unmanned vessels, it is necessary to underline the conclusions arrived with respect to the main question addressed within this master thesis, which is:

Determining if the current maritime legislation (as it is) is capable to face the legal challenges of autonomous vessels or if it is necessary to seek for further amendments, and in that case, how should those amendments be structured in both an international and a domestic perspective (Norway).

First of all, it is necessary to always bear in mind that in order to determine whether a specific regulation can be applicable to autonomous or unmanned ships or whether it needs to be modified for this type of vessels, it is necessary to analyze the level of automation of such ship during a specific navigation point (as set forth in Chapter 2.2 and 2.3).

At international level, the scope and application of the most important conventions relevant for liability and collisions: the UNCLOS and the 1910 Brussels Convention are discussed in this study.
The UNCLOS, considered to be the Constitution of the Seas, can be in general terms applicable to MASS, despite the fact that it contains articles that may be considered to be difficult to apply to controlled-remote and autonomous navigations in the way they are drafted today, if a strict interpretation of them is made. Here reference is made specifically to the duties of the contracting states (article 94).

As stated in this study, there are some circumstances that contracting states should verify with respect to the ships flying their flag, for instance, that they are properly manned and that the crew and master have appropriate qualifications, in particular in seamanship and others; as well as which application to autonomous and unmanned vessels will present a number of problems.

However, although an amendment could be required, the author considers that such an amendment will result into a difficult process\(^{51}\) of getting the consensus of half of the state parties in a decision-making process that would last approximately 2 years in a best-case scenario.

Therefore, it is necessary to find a better and easier alternative to get the UNCLOS to be applicable to unmanned and autonomous vessels. For such purpose, the author bases the following conclusion on these considerations:

(i) Article 91 of such convention states that every state shall fix conditions to grant the nationality to ships and therefore supervise the safety as a flag state and because of the nature of the convention itself; consequently each state will have within their own domestic jurisdiction the possibility of adapting the special rules to comply their duties within UNCLOS.

With this, a number of dispositions can be homologated to be technologically neutral through their own domestic jurisdiction by the establishment of neutral requirements to grant nationality to a ship.

\(^{51}\) As set forth in article 312 of the UNCLOS.
According to article 94(5) the states shall comply with generally accepted international regulations issued in terms of the compliance of these duties. In practice, those generally accepted international regulations refer to technical rules issued by the IMO.

Consequently, the issuance of rules for autonomous ships by the IMO in connection with the duties of flag states under UNCLOS would close this loophole and make the UNCLOS technologically neutral.

With respect to technical rules, the overall picture may not generate so many challenges although it will generate an important amount of work for the IMO and the issuance of a new generation of safety rules and regulations for autonomous and unmanned vessels.

The COLREGs are the set of rules that were developed to avoid collisions of whose breach may trigger a fault that will consequently lead to a liability. It is also important to remember that they were developed and issued by IMO and its members.

After the analysis of the COLREGs it was made clear that certain clarifications or small amendments to the current rules need to be developed in order to make such rules technologically neutral. The purpose of these clarifications or amendments will be to adapt not the rule itself but the way it is applied so that autonomous and unmanned vessels are also covered by the protection within safety set under COLREGs.

Therefore, the proposal in this respect is that IMO, within their scope of faculties, issues a specific document of written rules, that would be specifically applicable to COLREGs to be deemed as international generally accepted rules pursuant Article 94(5) of the UNCLOS and that:

(i) States the equivalence for terms and rules in COLREGs for autonomous and unmanned vessels, referring to their level of autonomy.

(ii) If it is required, add or create new rules for safety and avoiding collisions that will be only applicable to unmanned or autonomous navigation.
The purpose is to widen the scope of application of COLREGs without altering the Convention itself, but just by adding parameters and clarifications that make COLREGs technologically neutral and applicable to autonomous and unmanned navigation.

With respect to STCW, given the parameters within such Convention and the complications that may arise overall for its application to autonomous vessels, the author concludes that issuing a new Convention on Standards of Training, Certification and Watchkeeping for Seafarers is required, for both unmanned and autonomous vessels. It is important to consider that for the case of remote-controlled navigation, one would still have crew or master located at an onshore location, however regulated differently from traditional seafarers.

In connection with fully autonomous navigation, where no human intervention is required (not even for supervision), then a different chapter should be included in the new STCW that states the minimum requirements for seamanship and training that the algorithms and software programmed in the ship should have in specific navigation situations.

As it can be seen, this specific aspect for autonomous and unmanned vessels should be developed from the beginning with new consideration and new parameters and therefore, the author does not consider that there can be a way in which STCW can be homologated to be technologically neutral just by amendments.

Finally, it is important to remember that from all the current projects and prototypes that are being developed within automated navigation, all of them are to be executed within territorial waters of countries such as Norway\textsuperscript{52} and no long-term plans have been announced to change this situation and start operations in international waters.

Consequently, it is to be foreseen that domestic regulations will have to start with this legislative effort in the short term and international regulatory bodies such as IMO should accelerate the process of developing international rules in this respect, so that

\textsuperscript{52} As well Finland with the SVAN project developed jointly by Rolls Royce and Finferries.
all the leading countries may follow the same path and no future controversies arise from the application of opposite domestic rules.

However, a bigger problem can be anticipated when analyzing the 1910 Brussels Convention on Liability of Collisions in the High Seas.

As pointed out throughout this study, the current fault-based liability system regulated under such Convention could be applied to autonomous vessels with supervised automation and ability for human intervention without generating any additional challenges. However, for a fully automated vessel (AL5-AL6) the situation changes, as due to the specific risk of autonomous navigation it is necessary to regulate this activity differently as traditional navigation.

This is the reason that a change to strict liability to the shipowner is proposed—through a reversed burden of proof and a higher degree of care—, as no negligence or fault from the crew or master could be determined in such types of vessels. Most of the rules that have been developed on strict liability for maritime law base their considerations on the fact that “persons who engage in particularly dangerous activities must expect damage occasionally to result and it seems more appropriate for the particular business to have to carry the loss than third parties.” This principle is also called liability for dangerous enterprise.

The proposed liability system for autonomous vessels with full automation is a strict liability with a reversed burden of proof when the colliding party was negligent, in which case, the incident will turn into a fault-based system and liability should be apportioned accordingly. This burden of proof, as mentioned by Falkanger, may be deemed to be a type of strict liability that encompasses all the risks that the shipowner has to bear for the dangerous enterprise but with fairer grounds.

In order to make this proposal work, it would be necessary to amend the 1910 Convention, by adding a chapter specially for autonomous vessels with fully automation,  

53 Falkanger op cit. p. 193
setting out the principles for the change to the strict liability system as mentioned above.

The downside of making this amendment, is the same as with the UNCLOS: the time frame to get consensus can be a problem. In accordance with article 14 of the 1910 Brussels Convention, the Belgian government shall call a conference within six months after receiving a proposal of amendment or extension of its scope.

Another option, which is more drastic, would be that those states that wish to adopt this liability regime for fully autonomous vessels terminate the convention and issue this specific chapter within their internal law, in the understanding that they have already adopted the past provisions of the Brussels Convention regarding fault-based liability within their domestic law.

This specific scenario is still unclear as the consequences arising from the adoption of a specific regime of liability (strict liability) in the domestic legal framework may generate a breach to the Convention. However, it is the author’s opinion that contracting states could argue (as an ultima ratio argument) before the conference of the Convention that their domestic dispositions are applicable only for fully autonomous vessels and in no way are contradictory to the rules set forth under the Brussels instrument, which is applicable only to traditional vessels.

In connection to Norway, it is necessary to say that there is an important precedent where the Norwegian Maritime Authority (Sjøfartsdirektoratet) recommended to denounce the 1910 Brussels Convention in order to apply the HNS Convention for Hazardous and Noxious Substances, which imposes a strict liability regime to the ships transporting those type of substances as a consequence of the Consultative Meeting of Norway before the IMO54. “The problem is that the 1910 Collision Convention does not allow strict liability within its scope, while the liability under the HNSC is strict”. However, no actions have been taken in this respect by the Norwegian government.

With respect to the domestic legislation of one of the leading countries worldwide in connection with the development of autonomous and unmanned ships, it is important to say that Norway has already started with the efforts to regulate autonomous navigation. In April 2019 the Ministry of Transport and Communications passed a bill to the Parliament to regulate, among others, autonomous coastal navigation and more importantly, it stated a mandate to make all maritime law to be issued, technologically neutral. This means that they are drafted in such a way that they can be applicable to both traditional and autonomous navigation.

Specifically, in connection with collisions, the application of the NMC would need to have a different approach in terms of liability arising from ship-to-ship collisions in Chapter 8. Those non-statutory modifications should be directed to state the different technical features that will differentiate the level of automation of vessels, and the liability regime they would be subject to. Starting from the idea that fully automated vessels without any type of human intervention (or with sporadic supervision) will depart from the fault-based liability system established under the NMC and the 1910 Convention and would be part of a strict liability system. (with a reversed burden of proof).

It is of the utmost relevance to point out again the complications and challenges that will arise from this change of liability regime for signatory countries of the 1910 Brussels Convention. As addressed above, some of the options are to amend such Convention and introduce a new chapter for autonomous vessel or terminate it, with the understanding that its main dispositions have already been adopted by the signing countries and therefore all of them would have a uniform legal framework to start with. Therefore, the most important source for accomplishing the implementation of new rules and interpretations to the navigation of autonomous vessels is case law. Norwegian case law has been an important source within maritime industry and has set the base for settling important controversies when specific circumstances of the case required specific interpretation.

This source will be of specific help when switching the regime between fault-based liability and strict liability for autonomous vessels, as these rules still leave room for courts to adopt a specific interpretation within fault (please refer to the reversed burden of proof studied in this study).
On any case, it is clear that in order to maintain safety and reliability in the maritime industry for the navigation of autonomous and unmanned vessels, there is need for an important regulatory effort at both international and domestic levels to adapt current rules as well as develop new ones, including their national variations.

It is to be concluded that although the current regime can be adapted to some extent, specifically, liability rules for collisions require new rules and amendments that are different from traditional rules and that encompass the need of regulatory and jurisdictional actions at an international and domestic level.

It is important to recognize that work has been started, and that coordination efforts have been already developed, however, the first premise to be considered is that reality is always a step ahead from regulation, and therefore, not only the changes are urgent but they have to be coordinated and well assessed so they can be used on a long term basis.

“It is, of course, recognized by the CMI that a review of all conventions will be necessary, but that work can and should proceed on the conventions selected in order to establish a modus operandi which can be applied across the legal and regulatory framework. A further complication is that the various instruments emanate from different IMO subcommittees. So effective co-ordination is very important.”

International organizations such as the IMO and CMI are having a steady advance and a growing engagement with this topic, and it is through them, their members and all their collaborators that we now have a clearer overview of the regulatory needs of the industry in this respect. States such as Norway are assuming their role by developing new and technologically neutral regulations applicable to autonomous vessels and they are consulting to international companies and other organisms to have a better perspective of the challenges to tackle.

In the end, the joint efforts of all the parties involved - states, international organizations, technology companies, shipowners, insurance companies - and its level of commitment, will determine the success of this important regulatory task and mark a milestone in one of the world’s most ancient activities, the shipping industry.
List of Abbreviations

- AL - Autonomy Level
- CMI - Comité Maritime International
- COLREGs - Convention on the International Regulations for Preventing Collisions at Sea
- ICS - International Chamber of Shipping
- IMO - International Maritime Organization
- MASS - Maritime Autonomous Surface Ships
- MSC - Maritime Safety Committee of the IMO
- NFAS - Norwegian Forum for Autonomous Ships
- NMC - Norwegian Maritime Code
- STCW - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
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