# Autonomous Shipping and Seaworthiness: How Emerging Technologies Will Affect the Carriage of Goods by Sea

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## Introduction

The maritime industry has always been one of great change over time. From the Age of Sail transitioning to steamships and eventually modern cargo carriers, the type and manner of vessel has continually evolved with advances in technology. Once again the industry finds itself on the cusp of a significant shift in how we view the ship with the development of the unmanned vessel. Whether it be an autonomous or remotely controlled vessel, the removal of master and crew presents a significant potential for change in how the ship may be configured and operated.

One area that deserves consideration in the legal context is how this technology may affect the concept of seaworthiness. This is a legal concept that can be described as underlying "almost all aspects of private maritime law" (Chircop, Moreira, Kindred and Gold, 2016, p. 72). The autonomous and remote technology currently being developed raises many questions as to where the technology itself may fit within this definition and the requirements under maritime law and conventions. This paper will attempt to survey the technology of autonomous shipping as it currently stands, the legal concepts of seaworthiness most important to autonomous and remote technology, and assess how a potential shift in technology will affect this legal concept.

## The Technology of Autonomous Shipping

The International Maritime Organization ("IMO") has recently proposed a regulatory scoping exercise with this technology, referring to an overarching term for these advances as maritime autonomous surface ships ("MASS") (IMO, 2017, MSC 98/23, p. 79). While MASS technology contains a wide scope of potential uses, some of the applications are not new to vessels. Automation has previously been integrated into vessels through automatic course setting and some engine room functions (Chircop, 2017). Many satellite technologies and communications needed for unmanned shipping currently exist, however with regulations and other developments, the applications remain underutilized (Sampson, 2014, p. 58-59). What these technologies include and their broad scope of usage remains a debate among scholars, international organizations and those within the maritime and shipping industries.

An unmanned vessel, whether it is remote operated or fully autonomous with limited oversight, will always utilize some form of satellite transmissions to communicate its position and potentially further information to shore (Porathe, Prison and Man, 2014, 1.2). This communication from the vessel to shore is an integral feature of the technology (Porathe et al, 2014, 1.2). Short time intervals of only 4 seconds in these communications are seen as an ideal target to ensure safety and reliability (Porathe et al, 2014, 1.2). The reliability of these systems is integral to the operation of MASS and it is likely that a loss of satellite communication would result in a "fail-to-safe mode" such as dropping anchor (Porathe et al, 2014, 1.2). A key feature of these satellite communications will not necessarily be more data but rather ensuring that the right communications reach the shore, based on efficient and safe monitoring and control of a vessel (Burmeister, Brunh, Rodseth and Porathe, 2014, p. 10). Any shore-based personnel will need to rely on the available indicators while ensuring reliable communications and cost effective uses of data (Burmeister et al, 2014, p. 10).

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From a functional perspective, the essential data has been divided into nine groups by Porathe et all in their paper entitled "Situation Awareness in Remote Control Centres For Unmanned Ships" for the EU MUNIN project. While these groups do not represent the exact division used by the entire industry, they do assess many of the potential functions to be relayed to a shore based control centre by a remote or automated vessel. The nine general groups are identified as voyage, sailing, observations, safety and emergencies, security of cargo (stability and strength), technical, shore control centre and administrative (Porathe et al, 2014, p. 3).

Both the navigation and control will be of significant importance in the decision-making capabilities of a vessel to ensure compliance with maritime rules and regulations (Rolls-Royce plc, 2016, p. 3). Yet those programming these algorithms are likely not experienced seaman themselves. Rolls Royce describes this as an "interpretation challenge for the programmer" while noting that "development of control algorithms for autonomous vessels will be a gradual and iterative process and subject to extensive testing and simulation" (Rolls-Royce plc, 2016, p. 3).

A study by Blanke, Henriques and Bang (2017) outlined seven potential levels of automation for the navigational functions of a vessel. The seven degrees of potential automation are in order of lowest to highest level of automation for navigation:

1. Manual Steering – Steering controls or set points for course are operated manually.
2. Decision-support on board – Automatic steering of course and speed in accordance with the references and route plan given
3. On Board or Shore Based Decision Support – Steering of route through a sequence of desired positions.
4. Execution with human who monitors and approves – Navigation decisions are proposed by system based on sensor information.*
5. Execution with human being who monitors and can intervene – Decisions on navigation and operational actions are calculated by the system.*
6. Monitored Autonomy – Overall decisions on navigation and operation are calculated by the system. The operator determines goals and is contacted in case of uncertainty about the interpretation of the situation.
7. Full Autonomy – Overall decisions on navigation and operation are calculated by the system.

*The main distinction between four and five are that under the fourth a human will approve actions prior to execution whereas under the fifth a human will only intervene if necessary (Blanke et al, 2017).

These differences between navigational capabilities presents a very wide spectrum of what a MASS vessel's autonomy may entail. However, only the first three options still envision a crew of some form onboard. The remaining levels of functionality specifically consider what level of automation may be assigned to the vessel itself and what may be assigned to a human operator or supervisor, likely in a shore based control centre.

**The "Crew" of a Unmanned Vessel**

The considerations of a crew on a remote or autonomous vessel present a challenging aspect to assess. Many of these technologies remain in design and testing phases whereby the exact requirements for commercial operation have yet to be fully realized. On a standard vessel the question of who was a member of the crew has historically looked at the relationship to the ship, excluding those such as watchmen and caretakers employed while the ship is docked (Chircop et al, 2016, p. 377). Unfortunately the Canadian legislation does not precisely define crew or their roles. In Chwedczuk's analysis of crew in the United States ("US"), he elaborated primarily on two factors in considering who may be defined as a seafarer; those were location of work and the location for duties of employment (2016, p. 136-137). Typically under US legislation and case decisions, location near to the docks and shipping terminals would provide a positive factor in considering an employee as a seafarer (Chwedczuk, 2016, p.136). In the Canadian context "the crew of a ship must be related to the type of ship in question and the functions that need to be performed to enable the ship to perform as intended" (Chircop et al, 2016, p. 377). This suggests a slightly more flexible Canadian definition that may enable the remote operator or supervisor to be included for the purposes of crew, in relation to their specific type of vessel. Certainly their role would be in enabling a remote or autonomous vessel to perform as intended. It is also entirely possible that new categories may have to be imagined in order to properly assess these emerging roles, when contrasted with the traditional positions onboard a vessel (Chwedczuk, 2016, p.141).

The role of a master has been clearly defined under the *Canada Shipping Act*, SC 2001, c 26, s. 2, a master is defined as "the person in command and charge of a vessel." With a shift toward autonomous and remote technology this may be a challenging definition to consider. Is a remote operator truly in command and charge of a vessel? Or is it an automated program with limited human supervision, not originally considered when this definition was formulated. Chwedczuk notes that the imagined role of a remote operator is different in that "the owner of an unmanned ship will always have control over the vessel and its master/manager" (2016, p. 140). Chwedczuk further suggests that it may "not make sense to impose the same duties and liabilities of masters onto land-based remote operation managers when the original purpose of imposing said duties and liabilities is rendered obsolete" (2016, p. 140). It is entirely possible a new term and definition may be required under the *Canada Shipping Act,* when considering the role of a remote operator compared to the existing roles of master and crew.

**Defining Seaworthiness**

The legal notion of seaworthiness is concept of maritime law dating back to the 17th century (Chircop at al, 2016). The common law definition for seaworthiness of a vessel was described in *Kopitoff v Wilson* (1876), 1 QBD 377, by Justice Field as "seaworthy, that is, fit to meet and undergo the perils of the sea and other incidental risks to which she must of necessity be exposed in the course of the voyage." This appears to be an unclear definition of what exactly will be considered in making a ship seaworthy. It does however feature the most important concept, that is, the ship will be sufficiently ready to meet potential perils of the sea in a given voyage.

In responding to the potential differences in voyages, the notion of seaworthiness has been interpreted as a flexible concept. Justice Desjardins of the Federal Court of Appeal ("FCA") in *Laing v. Boreal Pacific*, 2000 CanLII 16313, described this as "seaworthiness is a relative term and varies with the nature of the voyage to be undertaken: its location, whether in a river, or canal, or on the ocean; the type of weather to be expected on the voyage, summer conditions or winter storms." This is an important consideration for both the concept itself and a MASS vessel operating on an algorithm based software program which must adapt and be able to assess the different challenges faced in a river or canal versus the open ocean.

These common law definitions of seaworthiness do appear to be consistent with that found in Canadian legislation. Under the *Marine Insurance Act*, SC 1993, c22, seaworthiness is described under Section 37(5) as "A ship is deemed to be seaworthy if it reasonably fit in all respects to encounter the ordinary perils of the seas in the marine adventure insured." While "seaworthiness" is defined within the *Marine Insurance Act*, a definition of the concept is noticeably absent despite several references to the term in both the *Canada Shipping Act*, SC 2001, c 26 and *Marine Liability Act*, SC 2001, c 6.

**The Legal Implications of Seaworthiness**

Before considering the minute details of seaworthiness as a concept, it is important to review the legal implications of this concept. Seaworthiness can be found throughout Canadian maritime legislation. Section 37(1) of the *Marine Insurance Act*, SC 1993, c 22 states "There is an implied warranty in every voyage policy that, at the commencement of the voyage, the ship will be seaworthy for the purpose of the particular marine adventure insured." This is not the case for a time policy, as there is no similar implied warranty under the legislation. However, the impact on voyage policies is clear in that the seaworthiness of the vessel will be held as an implied warranty under a Canadian voyage insurance policy.

The *Marine Liability Act*, SC 2001, c6, s 43(1) legislation codifies the International Convention for the Unification of Certain Rules of Law relating to Bills of Lading or "Hague-Visby Rules" for the international carriage of goods into Canadian law. This is likely the most important legislation in relation to seaworthiness and autonomous shipping. Both the carriage of goods within Canada and from Canada to other states is covered by Section 43 of the *Marine Liability Act*. The Hague-Visby Rules Article III are included within the *Marine Liability Act* as follows:

> 1 The carrier shall be bound, before and at the beginning of the voyage, to exercise due diligence to
> (a) **make the ship seaworthy**;*
> (b) properly man, equip and supply the ship;
> (c) make the holds, refrigerating and cool chambers, and all other parts of the ship in which goods are carried, fit and safe for their reception, carriage and preservation.
> (*Emphasis Added)

This requirement to exercise due diligence in making a vessel seaworthy at the outset of a voyage underlies almost all Canadian carriage of goods contracts. While seaworthiness is not actually defined within the Hague-Visby rules, Justice McHugh of the Australian High Court in *Great China Metal Industries Co. Ltd. v Malaysian International Shipping Corporation Berhad (The Bunga Seroja)* (1998) 158 ALR 1 noted that in the context of these rules "the term 'seaworthiness' should be given its common law meaning." Canadian courts have similarly considered this common law definition in the context of its historical use. This duty under Article III of the Hague-Visby Rules allows for an important limitation of liability on the part of a carrier. Under Article IV of the Hague-Visby Rules the following limitation is permitted "Neither the carrier nor the ship shall be liable for loss or damage arising or resulting from unseaworthiness unless caused by want of due diligence on the part of the carrier to make the ship seaworthy." Therefore as long as a shipowner and their agents exercised due diligence, they will be able to rely on this limitation of liability. It is important to note that when seaworthiness is raised in regards to a loss, the burden of proof is with the cargo claimant, who will attempt to raise the shipowner's failure in exercising their due diligence (Tetley and Wilkins, 1998, p. 891).

Finally while Article VI does permit contracting out of the due diligence for seaworthiness obligation, it cannot be done under the Hague-Visby Rules for "ordinary commercial shipments made in the ordinary course of trade." It can only avoided under the Hague-Visby Rules when "the character or condition of the property to be carried or the circumstances, terms and conditions under which the carriage is to be performed are such as reasonably to justify a special agreement." As one can see there are significant legal considerations of seaworthiness under Canadian law, a change in the very nature of the vessel itself will have a significant effect on the current governing legislation.

**What is Included in Seaworthiness**

Although the definition of seaworthiness as a concept itself is clear, there is limited guidance from the given definitions as to what is actually included in making the vessel seaworthy. Tetley and Wilkins describe seaworthiness as "two aspects: 1) the ship, crew, and equipment must be sound and capable of withstanding the ordinary perils of the voyage; and 2) the ship must be fit to carry the contract cargo" (1998, p. 877). The Australian High Court has also described seaworthiness in *Great China Metal Industries Co. Ltd. v Malaysian International Shipping Corporation Berhad (The Bunga Seroja)* (1998) 158 ALR 1 [*Great China Metal*], as the vessel "must be 'in a fit state as to repairs, equipment and crew". The court further stated that seaworthiness "effectively imposes an obligation on the carrier to carry the goods in a ship which is adequate in terms of her structure, manning, equipment and facilities having regard to the voyage and the nature of the cargo" (*Great China Metal*, (1998) 158 ALR 1).

Although these factors have been extensively considered by the courts in examining the seaworthiness of a vessel, MASS vessels present new issues. The removal of a crew presents an especially challenging interpretation. Will an autonomous program onboard a ship will be assessed as equipment? Or rather in a role traditionally occupied by crew? In attempting to envision these potential interpretations, further examination is needed as to how these categories have historically been interpreted and considered by the courts.

**The Master, Crew and Seaworthiness**

In *Standard Oil Co. of New York v Clan Line Steamers Ltd.* [1924] AC 100 (HL) [*Standard Oil Co.*], the House of Lords considered the difference between the efficiency of a master and potential ignorance to the "peculiarities" of a vessel. Lord Atkinson went on to state "There cannot be any difference in principle, I think, between disabling want of skill and disabling want of knowledge. Each equally renders the master unfit and unqualified to command, and therefore makes the ships he commands unseaworthy" (*Standard Oil Co.*, [1924] AC 100 (HL)). The conclusions of this case appear to be clear in regards to seaworthiness and the master of ship. Both his skill and knowledge will be considered in rendering a decision on whether a ship may be considered seaworthy.

The decision *Hongkong Fir Shipping Co. Ltd v Kawasaki Kisen Kaisha Ltd* [1962] 2 QB 26 (CA) [*Hongkong Fir*] considered not the failures of a master but rather the issue of an inadequate engine room staff in the warranty of seaworthiness. Justice Sellers in reaching his conclusion on this matter noted the vessel was not fit for "ordinary cargo service when delivered because the engine room staff was incompetent and inadequate and this became apparent as the voyage proceeded. It is commonplace language to say the vessel was unseaworthy by reason of this inefficiency in the engine room" (*Hongkong Fir*, [1962] 2 QB 26 (CA)). Finally in *Hongkong Fir*, Justice Salmon considered the legal test to be applied as "would a reasonably prudent owner, knowing the relevant facts, have allowed this vessel to put to sea with this Master and crew, with their state of knowledge, training and instruction?" (*Hongkong Fir*, [1962] 2 QB 26 (CA)). This is an important consideration with regards to the training and competency of a crew, potentially of a crew not onboard a vessel.

From both of these cases it is clear that a crew and master will be judged on their skill, efficiency and knowledge of a vessel in considering whether or not a ship is seaworthy. However, this cannot be confused with the negligence of the master and crew. These are two distinct concepts. White notes this distinction as negligence occurring when a seaman may have the basic abilities to perform his job, but falls below a reasonable standard of a prudent seaman (1995, p. 223). On the other hand a member of the crew falling below the standard for seaworthiness is one who "is to be considered 'incompetent' if he does not know how to do his job properly, i.e., he does not possess the level of capability or skill to be reasonably expected of an ordinary seaman of his rank" (White, 1995, p. 223)

**The Vessel's Equipment and Seaworthiness**

When considering the specific issues of technology with an autonomous vessel, the closest equipment considered thus far by the courts would be that of navigational equipment and radar. In *Chicksaw*, 265 F. Supp. 595, a master was aware of a defective fathometer (depth finder) onboard the vessel prior to sailing. The master was the only person with authority in the area at the time to have the device repaired and chose not to do so, as a result the vessel was held to be unseaworthy (*Chicksaw*, 265 F. Supp. 595). Tetley and Wilkinson also note that based on the advances in radar technology "one must conclude today, because radar, Loran and other electronic equipment are standard equipment aboard a ship of any size, their presence in good working order is essential to the vessel's seaworthiness" (1998, p. 914). However this does not necessarily mean that a lack of this technology will render a vessel unseaworthy. Courts have demonstrated a hesitation in requiring actual the presence of this technology onboard, instead focusing on it's operability when found onboard (Tetley and Wilkinson, 1998, p. 915). Yet the requirement for radar can be found under the *International Convention for the Safety of Life at*

*Sea* (“*SOLAS*”), 1 November 1974, 1184 UNTS 3 at Annex 16. It is certainly possible that a requirement for this technology could be inferred by the courts, especially as its importance increases with an unmanned vessel. It may also be worth considering a revisit of these technological requirements under *SOLAS* in the context of unmanned vessels. Based on the historical jurisprudence, at a minimum it could be inferred that the courts will expect all relevant technology onboard an unmanned vessel to be in working order. With that said, priorities as to the importance of specific technological aspects may only emerge as the technology develops.

**Seaworthiness of the Vessel**

The technology and equipment found onboard an autonomous vessel will almost certainly change the traditional notions of seaworthy equipment. However that is not to say that the concept cannot be flexible enough to accommodate them. Tetley and Wilkinson have observed that over time, radar and Loran have been required by courts to be kept in good working order to maintain seaworthiness (1998, p. 913). These technologies were almost certainly unimagined when the initial concept of seaworthiness was considered by the courts. The primary issue in this area will be how courts interpret the requirements for new technologies onboard autonomous and remote ships. However international conventions such as an updated version of *SOLAS* could provide some guidance on how to interpret specific technological requirements. To fully consider the abilities of an autonomous or remote system onboard a vessel, courts will need to engage in complicated analysis of the appropriate systems and algorithms for a given voyage with respect to the potential perils faced. This will likely take courts beyond the vessel itself and potentially into the actual adequacy of software programming, to analyze the seaworthiness of an unmanned vessel. It is likely that the as the level of automation on a given vessel increases, so to will the scrutiny in an analysis of it’s equipment.

**Seaworthiness of the “Crew”**

If one were to simply assume the absence of a crew onboard violated the warranty of seaworthiness, then an unmanned vessel could simply be considered unseaworthy on that very basis (Chwedczuk, 2016, p.142). However the reality is likely to be more complicated as governments, the IMO and others consider these emerging technologies.

When considering the seaworthiness of a crew based on the authorities surveyed, the *Hongkong Fir* case presents some consideration of the size of a crew requirement. In this case, Justice Sellers did not find the lack of seaman a determinative factor stating “If they had all been competent and efficient all might have been well notwithstanding the numerical deficiency of officers” ((*Hongkong Fir*, [1962] 2 QB 26 (CA)). If one were to stretch this case to the context of a shore control centre, then a competent and sufficient staff would likely be able to meet requirement, despite the reduction in actual numbers of people involved. It is also possible that the requirements for the safe manning of a shore control centre could be established under potential IMO regulation and Canadian legislation.

The considerations from the *Standard Oil Co.* case may also be adapted to the potential staff of a shore control centre. The concepts of sufficient “skill” and “knowledge” for the operation of a vessel remain of importance even in a non-traditional seafaring role. These standards could be easily translated to an on-land scenario and remain valid assessments for the seaworthiness of a crew.

The more recent case of *Papera Traders Co. v. Hyundai Merchant Marine Co.*, [2002] 1 Ll. L. Rep. 719 (Eng. Q.B.) (“*Eurasian Dream*”) presents a slightly more modern examination of the warranty of seaworthiness in relation to a crew. In the *Eurasian Dream*, Justice Cresswell of the London High Court noted that “Seaworthiness must be judged by the standards and practices of the industry at the relevant time, at least so long as those standards and practices are reasonable” ([2002] 1 Ll. L. Rep. 719 (Eng. Q.B.)). This is an important notion as it suggests that unmanned vessels could be judged on the reasonableness standard and practices of their class.

## Seaworthiness and Legislation

While the common law interpretations of seaworthiness may be more flexible, it is potentially the legislation that may prove most challenging for unmanned and remote vessels. The Hague-Visby Rules as found in Canada's *Marine Liability Act* were likely not written with the consideration of an unmanned vessel in mind. Specifically Article III (1) of the Hague-Visby Rules only requires a vessel to be seaworthy at the beginning of a voyage. This may have been sufficient for seaworthiness with an onboard crew when they remain on the vessel for the duration of a voyage. However with remote operators and supervisors, many persons may be involved with the navigation of a vessel despite never stepping foot onto the ship itself. They will not be onboard from point A to point B of a voyage. During the course of a shift or workweek, operators may instead come and go from a navigational station or change which vessels they control or oversee. Therefore the notion that a crew will be onboard and responsible for a vessel from the beginning of a voyage may become an out-dated notion.

One potential solution is the adoption of the Hamburg Rules, as they currently exist within the *Marine Liability Act*. While these do not directly address the concept of seaworthiness itself, they do hold the carrier liable under Article 5(1) that "his servants or agents took all measures that could reasonably be required to avoid the occurrence and its consequences" (*Marine Liability Act*, Schedule 4, Part 2, Article 5(1)). This would appear to present a more modern concept of the potential liability for a carrier in the context of unmanned vessels. The more recent United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea (New York, 2008) (the "Rotterdam Rules") also presents an option for modernizing the concept of seaworthiness within the provisions of that convention. These rules, which specifically consider seaworthiness, have extended the requirements of a carrier to maintain a seaworthy vessel throughout the duration of a voyage (Berlingieri, 2006, p. 9). While it is not the purpose of this paper to consider other issues with the adoption these conventions, they do at a minimum allow for a modernization of seaworthiness in comparison to the existing Hague-Visby Rules in Canada.

## Conclusion

The interaction between seaworthiness and unmanned vessels is a challenging one to assess. In many ways it will depend on how the technology develops and the involvement in human actors with these vessels. Legislative changes such as manning requirements under the *Canada Shipping Act* and limitations under the Hague-Visby Rules will likely require updating. The common law conceptualization of seaworthiness will likely be able to evolve through the courts. It has so far managed to adapt from the vessels of the 17th century to today and there appears to be no compelling reason it cannot continue to do so. This assumes that courts will be willing to take on an increasingly active role in the assessment of these technologies. It will require analysis that has yet to occur among previous technological advances in the maritime industry. That is not to say it cannot be done, it will just require flexibility and a willingness to embrace these emerging technologies on the part of courts in Canada and around the world.

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