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The Development of Maritime Autonomous Surface Ships: Regulatory Challenges and the Way Forward

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Abstract

This article investigates the legal and regulatory challenges associated with the development of maritime autonomous surface ships (MASS) as well as the extent to which MASS also referred to as autonomous ships may proffer solutions to the problem of human error often associated with maritime accidents. There is no denying that ship mishaps have been linked to a human error within the maritime industry over the years. Hence, exploring solutions that would help reduce maritime mishaps while also saving costs is an eminent step going forward. In addition to the lack of explicit legal framework to regulate the development of MASS, the article demonstrates how the extent conventions and rules may pose legal barriers and regulatory challenges to the development of autonomous shipping. It recommends progressive interpretation of the extant laws as well as the need to adopt international legal framework in the form of a MASS code, new convention on autonomous shipping or the amendment of extent laws especially the Law of the Sea Convention and rules of the International Maritime Organisation (IMO) in order to clarify states and stakeholders' obligations in relation to autonomous shipping.

Keywords

MASS, Autonomous Shipping, Legal Framework, Regulatory Challenges

1. Introduction

The invention and usage of autonomous ships, also known as maritime autonomous surface ships (MASS) are gradually becoming a common phenomenon. Although there are certain types of autonomous ships today, particularly mili-

tary surveillance and research ships, there are still no autonomous commercial ships (Cross & Meadow, 2017). These types of innovative endeavours are steadily becoming the norm in engineering, air and land transport. Similarly, this trend has been welcomed in the sea and marine industry. Many researchers in this domain note that autonomous ships will undoubtedly take over maritime industry (Yanchin & Petrov, 2020). There is no question that autonomous shipping is the future of the maritime industry and "as disruptive as the smartphone, the smart ship will revolutionize the landscape of ship design and operations" (Rolls-Royce, 2016). Rolls Royce, for instance, noted that by 2035, a voyage by an entirely autonomous ship will have taken place (Rolls-Royce, 2016).

Autonomous shipping has been invented due to the need to avoid human error which is a leading cause of most maritime accidents. Crewed ships have also been linked with high operating costs. The need to avoid the financial costs and human errors associated with crewed ships is a major driving force behind autonomous shipping innovations (Elspeth & van Hassel, 2021). The traditional operational and technical procedures such as reducing ship speed and increasing ship sizes were originally meant to reduce costs. However, these are currently unable to curb environmental, social, and economic challenges associated with crewed ships (Yewen et al., 2021). Hence, autonomous shipping is believed to be the linchpin for future sustainability and competitiveness in water transport.

This paper explores the legal frameworks for the regulation of autonomous shipping as a technological advancement to proffer solutions to human errors that are often associated with maritime accidents. It examines the justifications for the development of autonomous shipping as well as the issues of safety; privacy rights protection and the extent to which existing legal instruments may be relied upon for the development of autonomous shipping.

2. The Concept of Autonomous Shipping

Autonomous shipping is a new phenomenon that seems not to have been fully incorporated into popular literature. However, scholarship on the subject is growing gradually. The concept is not defined or mentioned in any international treaty. According to the Danish Maritime Authority, "autonomous ships are considered the overall term for ships capable of providing, via automatic processes, decision-support or a possibility of taking over parts of or the entire human control and management of the ship, irrespective of whether the control is exerted from the ship or from somewhere else" (Danish Maritime Authority, 2017). They are ships that are "capable of some kind of self-propelled operation in the seas regardless of presence of ship crews onboard" (Dremliuga & Mohd-Rusli, 2020). They are equipped with systems of artificial intelligence (AI) which replaces or takes over the functions of human crew. The International Maritime Organization (IMO), the global regulatory body for international shipping, defines MASS as "a ship which, to a varying degree, can operate independently of human interaction" (IMO, 2018), or a ship that is able to make decisions and determine ac-

tions itself.

It is important to note that unmanned vessels (UVs) are different from MASS or autonomous ships. UVs are vessels without crew on board but the vessels may be controlled remotely on shore. Autonomous ships or MASS are pre-programme vessels that operate using algorithms (Shipowners, 2017). The ultimate goal of autonomous shipping is the elimination of human control or human decision making in relation to the operations of ships. The IMO recognises four degrees of autonomy for the purpose of autonomous shipping (IMO, 2018), namely: crewed ships with automated processes and decision support (Degree One); remotely controlled ships with seafarers on board (Degree Two); remotely controlled ship without seafarers on board (Degree Three); and fully autonomous ship (Degree Four), where the ship is able to make decisions and determine actions by itself (IMO, 2021). Other organisations such as the European Commission have adopted a tripartite categorisation: namely "remote ship", "automated ship" and "autonomous ship" (Koscielecki, 2019).

In general, autonomous ships are linked to several state-of-the-art features that will increase their efficiency. They are expected to have an on-board control programme to make decisions on the entire ship handling. The system is programmed to convey data from an installed sensor (Yanchin & Petrov, 2020). Research indicates that such ships must consider the activities happening outside of them to maintain safety measures (Dmitriev & Karetnikov, 2017). Also, autonomous ships are expected to be fixed with remote monitoring sensors to measure sea dynamics and ensure seaworthiness (Yanchin & Petrov, 2020). Such sensors will enable the ship to transmit data to the onshore control panel, making it easy to monitor the ship's behaviour remotely, at least in the interim (Trudi & Ghosh, 2016).

3. Justifications for Autonomous Shipping

Contrary to human-crewed ships, autonomous ships have several merits including environmental advantage due to fuel savings, enhanced safety, increased cost-efficiency and improved infrastructure (Danish Maritime Authority, 2017). Most accidents involving ships happen due to human error. These accidents constantly cause pollution, destruction of aquatic animals and their natural habitat, and significant loss of revenues. Accidents automatically lead to the tragic loss of many lives. Considering that most sea accidents are commonly related to human error, safety measures are one of the main aims of autonomous shipping. According to Cross and Meadow, the crew is the primary source of challenges on-board (Cross & Meadow, 2017). Since there is no crew on autonomous ships, their effect on the ship's safety might be reduced. Between 75 and 96 percent of maritime accidents from 1912 to 2012 directly or indirectly resulted from human error (Elspeth & van Hassel, 2021). Thus, many researchers believe that autonomous shipping will help reduce these mishaps by eliminating navigation problems and the burden of fatigue, which have been established as the primary

contributor to human error leading to maritime accidents (Hans-Christoph et al., 2014).

Other than solving human errors associated with crewed ships, autonomous shipping is also projected to reduce the cost of operations and bring about efficient utilization of space design, effective use of intelligence and the crew, and more efficient fuel use. For example, research conducted by the Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) found that a single autonomous bulk carrier ship will reduce operation costs by up to 4.3 million USD in 25 years (Kretschmann et al., 2017). These statistics demonstrate the impending benefits of autonomous shipping in the maritime industry. However, there are numerous safety and legal concerns raised about uncrewed ships (Nakamura et al., 2019).

4. Legal Framework for the Regulation of Autonomous Shipping

The current legal regime governing shipping is strongly anthropocentric and regards human control as the most basic element for the safety of shipping. The law governing the sea was largely codified in 1958 in four conventions: Geneva Convention on the High Sea, Geneva Convention on Territorial Sea and Contiguous Zones, Geneva Convention on the Continental Shelf and the Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas (Umozurike, 1993). Most of these Conventions are declaratory of the rules of customary international law. The various rules in the four conventions have found their ways into the Law of the Sea Convention (LOSC) of 1982. The overall themes covered by maritime laws are symbolized by safety, the occupational health conditions of workers, product and technical homogeneity equipment for ships, shielding the maritime environment from any form of pollution, and ship-owners civil liability relative to wreck removal, adjustments, pollution, damages to people or goods and collision (Danish Maritime Authority, 2017). It is also worth noting that a ship voyage is protected by numerous national, international and private legal frameworks.

Much of the commentary on the regulatory challenges for autonomous shipping is focused on whether the traditional definition of ships could be extended to autonomous ships and unmanned vessels. The regulatory challenges emerge from different layers of laws including primarily the LOSC; other safety standards as laid down in separate conventions or adopted by the International Maritime Organization (IMO); national marine legislation; and in a limited number of cases, regional treaties and such as EU treaties relevant for maritime operations (Ringbom et al., 2020). This article focuses on the legal and regulatory challenges relating to or arising from the LOSC and other IMO conventions and rules. Questions have also been raised about the possible application to autonomous ships of the provisions of the various international conventions, especially LOSC, the International Regulations for Preventing Collisions at Sea

(COLREGS) 1972 and the International Convention for the Safety of Life at Sea (SOLAS) 1974. Unsurprisingly, these legal challenges arise because the various maritime conventions were drafted a long time ago without autonomous ships in mind.

The LOSC, rightly described as the "Constitution of the Ocean" dealing with the rights and obligations of states over the sea, enjoys widespread acceptance globally. It governs 'the extent to which ships can navigate in different sea areas, the obligations states have over ships flying their flag, and the rights of other states to interfere in the navigation of ships in different sea areas, among others (Ringbom et al., 2020). Some of the provisions of the LOSC would appear to be incompatible with autonomous shipping. For example, article 94 of the LOSC mandates the flag state to "take such measures…as are necessary to ensure safety at sea with regard, inter alia, to…the manning of ships, labour conditions and the training of crews, taking into account the applicable international instruments" including measures necessary to ensure "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" (Ringbom et al., 2020). This provision clearly requires that each ship should be managed by a master and officers who possess appropriate qualifications, and also that the crew is appropriate in number for the type and size of the ship. Since autonomous ships are unmanned, it poses a legal challenge whether the operation of autonomous ships would not be a contravention of these legal provisions. Another example is article 98 of the LOSC which obliges a captain to rescue people found at sea or other distressed persons unless if after assessing the situation, a serious danger to the ship, crew or passengers may result. How would an autonomous ship, crewed by artificial intelligence (AI), rescue people found at sea or be able to assess the seriousness of some danger to the ship and passengers?

Regulatory challenges posed to autonomous shipping also arise from IMO conventions and regulations, and there are over 50 of such conventions and regulations in force (Ringbom et al., 2020). The obligations set by IMO regulations are imposed on flag states but the eventual targets are ship owners who are not subject directly to legal obligations under international law. States meet their international obligations under IMO conventions and regulations by prescribing enforceable domestic legislation compatible with their international obligations. Most of the IMO rules and requirements were set several decades ago when autonomous shipping was not even imaginable. The IMO conventions that give rise to most legal questions are the International Regulations for the Preventing of Collisions at Sea 1972 (COLREGS), the International Convention for the Safety of Life at Sea 1974 (SOLAS) and the International Convention on Standards of Training, Certification and Watch keeping for Seafarers 1978 (STCW Convention).

For example, regulation 5 of SOLAS requires that the master of the ship should be "supplied with information…as is necessary to enable him by rapid…processes to obtain accurate guidance as to the stability of the ship under varying operating conditions". In the case of remote operation, this information must presumably be supplied to remote controllers. In case of fully automated ships, where no person is immediately in charge of the ship's operation, other solutions will be needed for the handling of such information, and it remains to be seen whether such solutions are considered satisfactory by the relevant maritime regulator. Regulation 16 expressly requires that every ship "carries personnel qualified for distress and safety radiocommunications". This regulation presents both legal and practical difficulty for autonomous ships. How would autonomous ships implement these standards? Even when such capabilities exist, the adequacy of any such arrangement will be subject to the satisfaction of the relevant maritime administration. Regulations 15 and 16 of SOLAS concern onboard training and drills and operations aimed at ensuring that the personnel charged with command of the ship are prepared in the event of fire to combat and contain it. At the very least, this provision presents a challenge for developers of autonomous shipping to come up with automation system that is able to respond to fire incident to the same extent as human crew. Unless MASS and autonomous ships are able to meet these standards or the rules are adjusted in their favour, the legality of their operations will continue to be in question.

Rule 2 of the COLREGS requires the Master and crew members to comply with the provisions of the Rules. Rule 5 requires every vessel to maintain a proper look out. To what extent can personnel remotely operating an unmanned ship from a control room constitute a Master or crew members for the purpose of Rule 2 of COLREGS? Would an unmanned vessel with fitted cameras constitute a "proper look out", and since UVs would be operating pre-programmed routes, to what extent would the unmanned ship be able to divert its course as quickly as possible when the need arises in response to a foreseeable danger?

Similarly, the provisions in Chapter VII of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW) do not require shore-based operators. It states, "the Convention shall apply to seafarers serving onboard seagoing ships" (Veal, 2018). Therefore, more regimes are required for remote operators and pre-programmers if autonomous shipping in the maritime industry is to become a reality. Regulation 2 (2) (2) in chapter VIII of STCW does not allow for the monitoring of ships outside. This provision, it would appear, hinders the development of fully autonomous ships.

Furthermore, the second rule of International Regulations for Preventing Collisions at Sea (COLREG) is particularly interesting in the realization of fully autonomous ships. It states, "nothing in these rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these rules or of the neglect of any precautions which may be required by the ordinary practice of seamen, or by the special circumstances of the case". Also, Section B of that law reads, "in construing and complying with these

rules, due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger." Similarly, on collision avoidance, COLREGs rule 15 states, "when two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel" (Porath, 2019). Altogether, these laws also partly require the presence of physical operators in a ship, the absence of which may hamper the realization of fully autonomous vessels in the sea.

Regulation 37 in Chapter II of the SOLAS Convention prohibits electronic badges, an aspect that looks to hinder the development of ships without crew (Danish Maritime Authority, 2017). The prohibition of the electronic badge by SOLAS will severely obstruct communication in relation to the electronic badge. Additionally, another law that seems to hamper the development of fully autonomous shipping is the STCW Convention in Chapter VIII, Rule 2 (2) (1) because it requires the crew of the approaching ship to wave a flag to ensure that they are physically present on the navigating bridge on indirect contact with the bridge control rooms and chartroom (Danish Maritime Authority, 2017). In order for unmanned ships to become a reality, the various laws cited above need to be revised to allow officers on the watch to be in locations other than the ships and for artificial intelligence to take up these responsibilities.

5. Preliminary Findings and Analyses

The regulatory challenges posed by autonomous shipping have been acknowledged by most experts in the maritime industry. Consequently, IMO's Maritime Safety Committee (MSC) has undertaken a regulatory scoping exercise to analyze relevant ships safety treaties, in order to assess how MASS or autonomous ships could be regulated, especially how to ensure that maritime regulations keep pace with technological advancements (IMO, 2021). The scoping exercise initiated in 2017 was completed in May 2021. The exercise assessed substantial number of IMO treaties, identified namely; provisions which applied to MASS and hinder MASS operations; provisions which though applied to MASS do not prevent MASS operations and so require no action as well as provisions which applied to MASS and do not prevent MASS operations but may need to be amended or clarified, and/or may contain gaps; or have no application to MASS operations (IMO, 2021). At the completion of the exercise, the IMO notes that "clarifying the meaning of the term 'master', 'crew' or 'responsible person' is a high priority" (IMO, 2021). Other high priority issues identified include: MASS terminology and definitions, the functional and operational requirements of the remote-control station/centre and the possible designation of a remote operator as seafarer. The Maritime Safety Committee (MSC) that carried out the exercise recommended the adoption of a goal-oriented MASS instrument in the form of a

MASS Code.

At the time of writing this piece, IMO's Legal and Facilitation Committees are in the process of conducting regulatory scoping exercises on conventions under their purview. While awaiting the outcomes of the various regulatory scoping exercises, it is possible to make some general evaluations of the nature of the legal challenges posed by autonomous shipping. There is no question that several provisions of extant treaties are applicable to MASS and may actually prevent MASS operations. One of the few instances of a direct conflict is the watchkeeping provisions of the STCW Convention. To the extent that the functions of watch keeping officers are performed by remote personnel or automated technologies, it remains controversial whether autonomous ships are in compliance with the requirements of physical presence on the bridge at all times as prescribed by the STCW.

While most of the IMO rules and provisions of the conventions do not directly conflict with the operation of autonomous ships, the provisions need to be interpreted or understood in a particulars way by all parties involved in order to make fully autonomous ships a reality. An issue which definitely requires legal confirmation is whether tasks and functions such as control, monitoring and management required by the various conventions to be performed by human personnel on onboard the ships may be performed legitimately from a remote location or by use of automated technologies mounted on the ship (Ringbom et al., 2020). For example, there is a need to confirm whether the master of the ship may be located somewhere else other than inside the ship and whether he or she can be in charge of several ships at the same time under existing legal regimes Also, rules that pertain to evacuation requirements, accommodation spaces and crew drills may need to be interpreted or understood in a different way for the purpose of unmanned or autonomous ships.

Despite the possibility of direct and indirect conflicts, we note that there are provisions in the various conventions, especially SOLAS, which permit states to exempt ships which "embody features of a novel kind" from compliance with some provisions of the conventions. These exemptions are applicable where the application of the provisions of the Convention "might seriously impede research into the development of such features and their incorporation in ships engaged on international voyages". These exemptions, it is argued, may be applicable to autonomous ships. If this interpretation is accepted, autonomous ships may be exempted from specific provisions of SOLAS and other conventions which may impede their operations. The underlying principle governing the safe manning of ships is that ships "shall be sufficiently and efficiently manned" (Ringbom et al., 2020). So long as technological solutions provided by autonomous ships achieve this goal, it should not matter that the functions are performed remotely or by automation rather than by humans. The fundamental truth however is that for autonomous ships to become a reality, the legal framework will need to change to accommodate the advent of autonomous shipping.

In the meantime, the development and use of autonomous ships will depend more on IMO rules and national policies than on the rules of LOSC. States generally have broad discretion to exempt certain ships from technical requirements under SOLAS, provided the state is satisfied that safety standards are not compromised. Accordingly, states that wish to implement a trial of autonomous ships may do so without any impediments within their territorial waters. It must be noted, however, that other states may deny access to foreign unmanned ships in their internal waters if the operation of such ships conflict with their national laws. Thus, the development of regulatory framework for MASS cannot be left to the whims and caprices of states. In the long run, an international instrument in the form of a MASS Code or a Code of Practice for Autonomous Ships adopted under the auspices of the IMO will be needed to regulate the development and operations of autonomous ships.

6. Conclusion

This article examined the merits for autonomous shipping as well as the implications of the absence of legal instruments for the development and regulation of maritime autonomous surface ships (MASS). It observed that there are legal, formal and conceptual barriers that make the current maritime laws inapplicable to autonomous shipping. Under the extant legal regime, the captain and other crew members in a ship bear the responsibility and obligation to comply with the pertinent maritime laws and regulations. The question remains: who bears the responsibility of the captain and the crew members in autonomous ships?

Autonomous shipping aims to reduce the involvement of physical operators in the ship. However, maritime laws require the physical presence of operators. Additionally, most of these laws do not give any direction for remote or offshore operators. Therefore, such rules will perhaps need to be changed if features such as the collision avoidance mechanism that is not dependent on physical supervision are to be incorporated. Overall, the IMO needs to adjust old rules or adopt new ones to accommodate more technologically advanced ships including MASS.

The first step to address the legal barriers and regulatory challenges is to interpret existing legal instruments in a progressive way. There is also a need for an international legal framework in the form of a MASS Code as suggested by the IMO's Maritime Safety Committee (MSC) or some amendments to the LOSC and other IMO conventions to regulate and govern the development and safety of autonomous shipping. However, in view of the fact that the adoption of new international convention may take several years, it is likely that the development of autonomous ships will have to continue in spite of the lacuna in the conventions.

From most of the observations made on the new inventions expected in the maritime industry, it is clear that maritime laws need considerable re-evaluation. Accordingly, the regulatory scoping exercise being conducted by the IMO's Legal and Facilitation Committees are on conventions under their purview is a

welcome development. The IMO needs to extensively assess the rules and regulations that will pave the way for autonomous ships while still maintaining or upgrading the safety standards. For instance, various provisions of the SOLAS and COLREG conventions require the presence of physical operators. These provisions will need to be re-examined as they may hinder the development of a fully autonomous vessel. Also, there is a need for common interpretation and understanding between regulatory apparatus such as SOLAS, COLREG, and STCW within the provisions of IMO with respect to every level of autonomous ship. Regulation 2 (2) (1) in Chapter VIII of STCW needs to be revised to allow officers to monitor ships while in strategic locations other than where the ship is located. SOLAS also needs to allow the use of an electronic bridge for communication if every level of autonomy is to be achieved.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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