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Game Change: A Critical Review of Applicable Collision Avoidance Rules between Traditional and Autonomous Ships

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Abstract: Since the rise of intelligent control and multi-sensor integration technology, the development of autonomous ships has been significantly growing over the last decade. This advancement has painted a picture of extreme change with a radical alteration of human factors and new operating models. Inherent with the development of such ships, some concerns regarding their safe operation and integration into the maritime regulatory framework arose. Although the introduction of autonomous vessels is not an impending factor, it is the future, and one day will come into application. The primary concern inherent in the development of autonomous ships is compliance with the current International Regulations for Preventing Collisions at Sea (COLREGS) 1972. This paper uses an interdisciplinary approach to examine autonomous vessel seaborne interactions. The results show that we should actively support the modernization of the maritime industry and integrate it with other autonomous industries in the world.

Keywords: autonomous ships; collision avoidance; COLREGS; seafarers; navigation

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1. Introduction

Modern technological improvements have sped up the advancement and adoption of increasingly intelligent navigation systems in vessel operations and generated a favorable environment for the development of autonomous shipping. Although the introduction of the idea of maritime autonomous surface ships (MASSs) is recent, there has been substantial development and research activity in the maritime industry and it is predicted to generate various safety, economic, and environmental benefits. The idea of automation technologies in commercial ships is not new. Detailed discussions on automation in vessels at the regulatory level can be found in the 8th session of the Maritime Safety Committee of the Inter-Governmental Maritime Consultative Organization in 1964 [1]. Nevertheless, the regulatory and technological advancements of MASS have recently sped up, with interest and comprehensive research and development from policymakers, industrial practitioners, and researchers. According to UNCTAD [2], the MASS market is quickly expanding and is expected to reach $1.5 billion before 2050.

There has been a large amount of scepticism toward the introduction of autonomous vessels: whether they can fit in with current collision regulations, what changes will need to be made, and quite simply, whether they are necessary. Undoubtedly, there are contrasting views on the introduction of unmanned ships. The shipping industry has historically been regarded as a reactive rather than proactive industry when addressing potential and predicted future predicaments. Though the introduction of autonomous vessels is not an impending factor, it is in the future, and one day may come into application. However, such introduction into legislation will not formally happen until a formal proposal has been

made from a member state, requiring further ratification from member states to install it into legislation. The International Maritime Organisation (IMO) has begun to recognise the potential call for clarity on the role of autonomous vessels on the high seas and have started investigating in this area. In December 2018, the IMO's 100th Maritime Safety Committee (MSC) approved the framework for a regulatory scoping exercise on MASS.

The scoping exercise on MASS has so far determined the degrees of autonomy that are to be recognised upon further development of the technology [3]. The degrees of autonomy have been categorised as the following:

1. Degree one: ship with automated processes and decision support. Seafarers are onboard to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised, but there are seafarers onboard ready to take control.
2. Degree two: remotely controlled ship with seafarers onboard. The ship is controlled and operated from another location. Seafarers are available onboard to take control and operate the shipboard systems and functions.
3. Degree three: remotely controlled ship without seafarers onboard. The ship is controlled and operated from another location. There are no seafarers onboard.
4. Degree four: fully autonomous ship. The operating system of the ship can make decisions and determine actions by itself.

The four degrees of autonomy provide a method for addressing the various types of operations a MASS may perform, "taking into account, inter alia, the human element, technology, and operational factors" [4]. However, the development and introduction of MASS consequently require the IMO to consider the amendment of current regulations, such as SOLAS, STCW, MLC, and COLREGS. Furthermore, IMO must consider developing and introducing new regulations that will be relevant to new technological developments. Autonomous vessels are a relatively new concept for the operation of ships on the high seas and will undoubtedly create unprecedented issues for those responsible for making the necessary changes to current regulations.

This paper aims to provide a critical review of applicable collision avoidance rules between traditional and autonomous ships. It evaluates certain hypothetical and likely future scenarios, focusing only on the interaction between a manned vessel and an autonomous vessel. Clarifying how, in an encounter, the current International Regulations for Preventing Collisions at Sea (COLREGS) 1972 will come into play and what amendments may need to be made. Furthermore, we attempt to establish the potential criteria by which an autonomous vessel may be categorised.

This paper is mainly divided into seven sections. Section 1 provides the research background, settings, objectives, and development of autonomous vessels. Then, Section 2 discusses international law and regulatory issues regarding autonomous vessels. Section 3 focuses on the methods employed in this research. Section 4 identifies the IMO scoping exercise and the COLREGS. MASS without privileges and MASS with privileges are investigated in Sections 5 and 6, respectively. The future research directions and key points are addressed in Section 7.

2. International Law and Regulatory Issues of Autonomous Vessels

International law plays a pivotal role in dictating the standards by which ships must perform, but more specifically, the United Nations Convention for the Law of the Sea (UNCLOS) outlines obligations required of the flag state and the navigational rights of ships [5]. The intended role of UNCLOS and other international rules is to reduce ambiguity for trading vessels, by clearly stating and defining the prerequisites of a "ship" or a "vessel". Yet, the fundamental problem arising from UNCLOS is the distinct lack of a definition for the term "vessel" and "ship", with the use of both terms being applied in inconsistent contexts. The quandary raised for the prospect of autonomous shipping is whether they are, in fact, 'ships'. This is a matter requiring great clarity on an international level, because if a unified definition cannot be achieved, the likelihood of a MASS registered to a flag

state being permitted into foreign waters seems unlikely. Furthermore, the point at which a craft is classified as a ship determines the liability of those involved—such was the case in Merchants' Marine Insurance Co Ltd. v. North of England Protection & Indemnity Association. The case concerned a collision between a ship, the Fernhill, and a floating pontoon. The pontoon could move, had the credentials of a ship, and had been adapted to provide for inhabiting or being manned by staff. However, due to its nature of not being designed for typical navigation, it was exempted from any liability.

What constitutes a "ship" is questionable and there lacks any singular definition under English law. However, the current common denominator is that all ships maintain a human element, particularly regarding the bridge team. With autonomous vessels, this element is fleeting [6].

For the legal consideration of MASS, there must be distinct clarity on what constitutes a "vessel" or "ship" and how MASS will be considered under such observations. If the conclusion is that MASS is, in fact, a "ship", it will have to operate under current navigational rules, withholding zero privileges over its conventionally practicing counterparts. If it is decided that a MASS is not a "ship", the question arises whether such objects should maintain the right to operate on the high seas and to what extent [7].

Insuperable conflicts have previously arisen when looking for a common interpretation of the word 'ship'. In the case of R v Goodwin, where two jet skis had collided, the defendant, Mark Goodwin, was indicted on a single count of conduct endangering ships, contrary to Section 58(2) (a) Merchant Shipping Act 1995. This states, "if a person, while onboard his ship or in its immediate vicinity, does any act which causes or is likely to cause the death of or serious injury to any person, he shall be guilty of an offence". During his judgment, Lord Phillips CJ concluded, "While it may be possible to extend the meaning of ship to vessels which are not employed in trade or business or which are smaller than those which would normally be so employed if this is taken too far the reduction can become absurd". The foundation of the court's interpretation of 'ship' brings the critical argument to questioning the word 'use', for which the court then relied upon the comments made by Sheen J in Steadman v Scofield in 1992, "A vessel is usually a hollow receptacle for carrying goods or people. In common parlance 'vessel' is a word used to refer to craft larger than rowing boats and it includes every description of watercraft used or capable of being used as a means of transportation on water".

Bill Tetley has observed that the definition of 'ship' and 'vessel' largely varies from one convention to another, due to the fact they are "very much a function of the subject matter concerned" [8]. The United Nations Convention on Conditions for Registration of Ships regards a 'ship' as "any self-propelled sea-going used in international seaborne trade for transport of goods, passengers, or both, except for vessels of less than 500 gross registered tons" [9]. On the other hand, the COLREGS consider a 'vessel' to be "every description of watercraft, including non-displacement craft . . . capable of being used as a means of transport on water" (COLREGS n4).

Inconclusively, a vast quantity of marine law does not provide any such definitions for a 'ship' or 'vessel. This is evident in the '1910 Collision Convention, 1910 Salvage Convention, 1952 Ship Arrest Convention, 1999 Ship Arrest Convention, 1926 Convention of Maritime Liens and Mortgages, 1993 Convention on Maritime Liens and Mortgages, and LLMC convention' [7]. The Hague-Visby rules regard a ship as "any vessel used for the carriage of goods by sea". The recognition of a ship or vessel may appear to be a clear observation, but in legal contexts, definitions can have quite distinct differences. Previous interactions with autonomous crafts have offered little clarity in the legal proceedings under international law, with different nations taking contrasting stances. In a previous diplomatic incident where the Chinese authorities confiscated a surfaced American "Unmanned Underwater Vehicle" (UUV). An argument arose over the 'status' of the object and proceedings within international law. The USA regarded the UUV as a "vessel", making it entitled to the required international law governing any other "vessel" on the high seas [10]. In contrast, the Chinese authorities concluded that the UUV was an "unidentified device",

which gave it to zero immunity under UNCLOS. The incident promotes the discussion of the rights of MASS at sea, whether they constitute "ships", are subject to follow the same rules and can display the same lights as their conventionally manned counterparts. However, if they are considered as a craft rather than a ship, they would not have the right to trade on the high seas, and they would have to follow an alternative set of requirements when performing trade on an international scale [11].

Rule 2 of the COLREGS provides overriding precedence on the requirement for a human element in avoiding collision, narrowing it down to "the ordinary practice of seamen". However, for the remaining discussion of rules in the COLREGS, the ability and duty to act is placed on the practice of the vessel and not the seafarer. Similarly, Article 3 of the Collision Convention 1910 refers to the error of the ship, rather than the crew [12]. This inconsistency across the maritime industry regarding regulation creates ambiguity for performing vessels and the introduction of autonomous vessels, particularly when considering compliance with Standards of Training, Certification, and Watchkeeping for Seafarers (STCW). The rules about watchkeeping is undoubtedly an element of current regulations subject to further review. Watchkeeping predominantly falls within the confines of the STCW convention, particularly in the section concerning "standards regarding watchkeeping". Part 4.1 Chapter VIII of the code remarks that "at no time shall the bridge be left unattended" and dictates in paragraph 24.2 that the officer on duty may in no circumstances leave the bridge unattended until properly relieved. The seaworthiness and safety of a ship are partly attributed to the competence of the crew members onboard and the properly manning of the ship. This matter was clearly illustrated in *Hong Kong Fir Shipping Co v Kawasaki Kisen Kaisah*, where the court constituted that insufficiency and incompetency of the crew rendered a vessel unseaworthy [13]. The leading purpose of the STCW convention is to ensure the safe practice of vessels when underway and is currently catered to manned bridges. However, this does not mean that it cannot change. If it is shown that an effective bridge monitoring system can be achieved via round-the-clock remote bridge monitoring, then there is no reason for the convention not to be adapted to the requirements of autonomous vessels.

Concerning the safety and disputes of autonomous vessels, the Safety of Life At Sea (SOLAS) convention assigns an obligation to the master to assist other ships or persons in distress in the vicinity [14]. The ability to exercise such obligations becomes a prominent issue when considering autonomous vessels. The liability of the master when failing to exercise such a requirement does not fall on the ship owner, but if the shore-based operator (SBO) of an autonomous vessel is in control, they could potentially be liable under legal contexts by being considered the 'master'. Therefore, this bestows a duty to assist in a distress situation on the SBO and may result in liability should it fail to do so.

SOLAS chapter V, regulation 10 states: "the master of a ship at sea which is in a position to be able to provide assistance, on receiving a signal from any source that persons are in distress at sea, is bound to proceed with all speeds to their assistance, if possible informing them or the search and rescue service that the ship is doing so".

The wording of the above statement comes into dispute with an autonomous vessel being in a "position to be able to assist". If a MASS is unmanned, then it is questionable as to how much assistance could be provided in a distress situation. It would not be out of the question to argue that it is not practicable for a MASS to provide emergency assistance, which would lead to exemptions from such situations. A proportion of MASS will be 'unmanned' and will lack the facilities to cater to human passengers, nor will there be lifeboats or SOLAS packs typically found on a manned vessel. The likely duty of the MASS in such a circumstance would be to assume the role of 'on-scene command' and liaise communications between the rescue team and distress location.

3. Methods

The maritime industry is subject to multi-level governance, which has been defined as 'a system of continuous negotiation among nested governments at several territorial tiers (supranational, national, regional, and local) as the result of a broad process of institutional creation and decisional reallocation' [15–17]. The significance of policy-making in the maritime industry connects with different jurisdictional levels and interested parties. The scope of documents for analysis not only includes international conventions and recommendations, but also extends to handbooks, guidelines, and rules related to legal instruments. For a better understanding of the background of the instruments, the analysis would also need to cover working reports, papers, and proceedings of the meetings and conferences of international organisations. These documents help to explain how a resolution was made and the major issues that different stakeholders were concerned about during this process. It is always a good practice for the researcher to examine whether the information gathered was broadly corroborated by other people and other sources. When looking for themes in the existing literature, it is important to avoid basing findings on a single source, and looking for information that is consistent across several sources. When themes emerge across a number of sources, it is reasonable to believe that these sources are verified by each other. The main objective of this research is to provide a critical review of applicable collision avoidance rules between traditional and autonomous ships. For example, IMO has recently completed a regulatory scoping exercise on Maritime Autonomous Surface Ships (MASS) that was designed to assess existing IMO instruments to see how they might apply to ships with varying degrees of automation. To achieve this objective, our research takes an interdisciplinary approach, including both sociology and legal studies. From a legal perspective, this paper relies on the analysis of policy documents related to traditional and autonomous ships. From the sociology aspect, this paper examines the responses of different stakeholders to the introduction of autonomous and remote-controlled ships. In order to do this, we employed a qualitative methodology approach.

This paper involves a review of the relevant literature, a critical step in the research process, and itself constitutes an important research method. At the same time, this review examines the changes in development in legislation and in practice, and the implementation of relevant international and national standards. Through policy document analysis, information can be extracted to explain how the industry responds to the changing international policy-making environment and how these responses improve and perfect international standards. In order to do this, we drew from the primary data collected from the industry through WeChat and QQ Talk with contacts in China. WeChat and QQ Talk are the most popular phone-based chat applications that are widely used among Chinese people. As such, such communication platforms can be used for individual interviews with interviewees. The duration of each interview lasted for 60 min. A total of 32 semi-structured, in-depth interviews were conducted with ship owners, ship managers, policy-makers, and seafarers from 2021 to 2022. Most of the interviewees came from our personal networks, to ensure a good response rate and observe the attitude and behaviors of the participants. Indeed, the participants sought rich working experiences in the maritime industry to make sure that they would provide accurate responses to our study. Their valuable insights have been incorporated it into the discussion of the research study. To maintain confidentiality, personal details of the interviewees are not disclosed in the study.

4. IMO Scoping Exercise and the COLREGS

The IMO has formally recognised the issues arising from the development of MASS and has consequently begun discussing how current regulations and conventions will need to be amended to maintain the safe practice of trade at sea. The IMO routinely organises scoping exercises within the MSC to create a formalised structure for developing amendments to current legislation.

The initiated sessions of the IMO MSC formally took the first steps to addressing autonomous ships in their 99th session, and began the regulatory scoping exercise for autonomous vessels in May 2018. The scoping addresses fundamental issues from SOLAS, COLREGS, Load Lines, STCW, search and rescue (SAR), tonnage convention, and safe containers (CSC). As per the 101st MSC session, adoptive amendments have been made and are set to practice as of 21 January 2024. The amendments thus far have been regarding compliance with SOLAS, MARPOL, and e-navigation, which is defined as "the harmonised collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronics means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment" [18].

Despite the current discussion of amendments to maritime regulations, there remains a surplus of discussion regarding COLREGS. The MSC held its 103nd session in 2021 and approved a circular related to the use of MASS, particularly between manned and unmanned vessels. The slow production of autonomous vessels will undoubtedly mean most vessels cruising long distances across international waters will remain conventionally manned. However, when the situation does arise for autonomous vessels, there needs to be a set protocol for the rules of engagement with the interaction between an autonomous vessel and a 'traditionally' fully crewed vessel. The continuous increase in trade on an international scale unsurprisingly places more ships in international waters, making the COLREGS paramount to improving the safety of navigation [19]. Thus, it is essential to place well-trained officers on a ship's bridge to reduce the chances of a collision.

The International Regulations for Preventing Collisions at Sea (COLREGS) 1972 have so far provided the remarkable issue of introducing autonomous vessels, with questions arising over the interaction between MASS and manned vessels. The biggest queries include whether an autonomous ship can comply with the current rules, whether they need to be adapted, and if so, to what extent.

The COLREGS were designed and introduced to set a safe standard of navigation for ship officers at sea, but with the development of MASS, questions arise whether these new ships would compromise the sole purpose of the regulations.

The code functions as a 'rule of the road', by providing clear and precise instructions as to how vessels and their officers are to engage when encountering other vessels. The purpose of these regulations is to reduce ambiguity on the high seas by clearly stating what constitutes a stand-on vessel from a give-way vessel and what actions must be taken in overtaking, crossing, and head-on situations. In addition to actions in avoiding collision, the COLREGS cover requirements for sounding signals and state the correct lights/day shapes to be displayed for a particular vessel.

In conjunction with the COLREGS, Regulation 14 of Chapter V of SOLAS provides the specific requirements for safe manning to ensure navigational safety, which is further supported by the flag state that issues the safe manning coding for vessel tonnage. Table 1 illustrates the manning requirement guidance issued by the MCA under the merchant shipping regulations, 2015, and STCW (MSN 1868 M). An argument in favor of unmanned ships is that, despite the requirement for trained officers in bridge watchkeeping, there remains a surplus of good seamanship and this seems to be an issue unlikely to change with continuously manned bridges. It has been concluded by recent studies that more than 80% of collisions at sea are due to human error, therefore emphasizing the grave risk of human interaction on the high seas [20]. The current collision regulations are written for manned navigation. However, suggestions have been made as to how a MASS could be introduced into the current regulations and whether adjustments will need to be made [21]. Subject to continuous review of the current collision regulations, there appear to be two scenarios in which unmanned ships may abide by the regulations:

1. MASS without privileges;
2. MASS with privileges.

Table 1. Flag state safe manning requirements [1].

Trading Area	Size of Ship (GT)	Number of STCW Certificated Officers to Be Carried				
		Master (II/2)	Chief Mate (II/2)	OOW (II/1)	Master (II/3)	OOW (II/3)
Unlimited	3000 or more	1	1	2	-	-
Unlimited	500 or more but less than 3000	1	1	1	-	-
Unlimited	Less than 500	1	-	2 (a)	-	-
Near Coastal	3000 or more	1	1	1	-	
Near Coastal	500 or more but less than 3000	1	1	1 (b)	-	-
Near Coastal	Less than 500	-	-	-	1	1

5. MASS without Privileges

The clear point of contention is the introduction of MASS without any privileges over conventionally manned vessels. Nevertheless, this would require amendments to the current COLREGS, ideally with minimal changes. MASS would be expected to maintain the ability to provide a full appraisal of collision situations.

Rolls Royce developed algorithms in their MAXCMAS project that enabled the existing COLREGS to remain relevant for an unmanned vessel. This has been confirmed by the project partners at Lloyds Register, Warsash Maritime Academy (WMA), Queens University Belfast, and Atlas Electronic (AEUK) [22]. Through the utility of WMA simulator suits, which are purposely designed for training seafaring officers and masters, MAXCMAS was able to run a series of trial runs to gauge how seafarers reacted to approaching autonomous vessels. Furthermore, this helped to distinguish exactly how a MASS would react to human interactions in various types of collision situations [23]. The study used collision avoidance module software (CAM), which continuously analysed fixed or moving objects within the vicinity, to measure potential collision risks. Furthermore, CAM performed calculated maneuvers when a collision situation was evident [23]. The CAM consisted of four key modules: decision-making, path re-planning, risk assessment, and situational assessment. Ralph Dodd, the Innovation & Autonomous Systems Programme Manager, AEUK, said:

"The trials showed that an unmanned vessel is capable of making a collision avoidance judgment call even when the give-way vessel isn't taking appropriate action, What MAXCMAS does is make the collision avoidance regulations applicable to the unmanned ship" [24] (Dodd, 2018).

The study showed that MASS can follow regulations and act accordingly in:

1. Overtaking situations (Rule 13);
2. Head-on situations (Rule 14);
3. Crossing situations (Rule 15);
4. Action by give way vessel (Rule 16);
5. Action by stand-on vessel (Rule 17).

The dispute of Rule 5 "lookout" continues to be raised for MASS, as they cannot maintain the full appraisal of a traditional lookout, as stated by Rule 5:

"Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions to make a full appraisal of the situation and the risk of collision" (COLREGS R5).

The wording of Rule 5 undoubtedly infers human intervention regarding the sight, sound, and competency of the onboard watchkeepers [25]. A MASS vessel is unlikely to rely on the requirements of Rule 5 and the use of 'sight' and 'hearing' in its actions to avoid a collision; instead, it would operate programmed collision avoidance algorithms and maintain intensified spatial awareness through onboard technology, as demonstrated by MAXCMAS. However, this does not strictly abide by the conventional monitoring techniques expected of current bridge teams.

Few favorable decisions have been made in the cases of laws regarding the omittance of a "lookout" by sight. The English judicial system has previously provided a case allowing the dismissal of Rule 5 in aid of shore-based assistance. The case of the "Nordic Ferry" from 1991 found that the vessel "could have sought advice from the fog watch pilot on duty in the Harwich Harbour Operations Room ... this would have been better than continuing without assistance and proceeding down the channel on the wrong side" [26]. The technological advancements introduced into the bridge environment have continuously been regarded as a crucial element for maintaining a safe and effective lookout, and case law recognized its ability for exercising Rule 7 by "using all available means appropriate" (COLREGS R7).

From current examples, it appears evident that if an automated system sustains the ability to avoid collision and maintain a lookout by alternative means, then all that is required is a technical amendment to Rule 5 [10]. If the IMO were to adjust Rule 5 by stating "all manned vessels ... by sight and hearing," they would immediately relieve MASS of current predicaments regarding the 'lookout'. This would allow IMO to create an additional rule for MASS considering "lookout by all available means".

6. MASS with Cruising Privileges

The COLREGS, as they stand, are based upon the principles of privileges for vessels operating under different circumstances or based upon their position to another vessel [27]. The prominent issue is whether rights are to be given to machines over humans, considering reducing human error and the risk of life at sea. If two manned ships are on a collision course, there is presently a double risk of human error. However, if a manned vessel is on a collision course with an unmanned vessel, the risk factor is reduced by half, particularly if the MASS is operating with a distinct set of privileges [28]. If there is an interaction between two MASS, then the risk is significantly reduced.

One proposition is that degree four autonomous vessels be regarded as Not Under Command (NUC). The Maritime UK notes, "If it can be demonstrated that, for a particular vessel, full compliance with the regulations is impracticable, then the application can be made to the Administration when considered necessary, via the RO, for consideration of exemptions and equivalent arrangements, taking into account the class and nature of the operation of the vessel concerned" (Maritime UK, 2018). The COLREGS Rule 2 (b) further states that "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 limitations of the vessels involved, which may depart from these Rules necessary to avoid immediate danger." (MSN 1781).

In alignment with Rule 3 (f), the term "vessel not under command" means a vessel that, through some exceptional circumstance, is unable to keep out of the way of another vessel. The exceptional circumstance of a MASS is that it is unmanned (Figure 1).

MASS vessels are expected to perform under different modes of autonomy and the ideology of the MUNIN project 2013–2015 was for an autonomous vessel to be crewed up until the point of pilot drop off and fully autonomous thereafter until the pilot pick-up point at the next destination (MUNIN 2016). In this case, it would be required for the MASS to be identified as a NUC for the deep-sea leg or once 12 nautical miles offshore; for a MASS vessel to identify as a NUC, it would be required to display the correct navigation marks as stated under Rule 27 of the COLREGS. It would need to exhibit:

(a) Two all-round red lights in a vertical line where they can be best seen;
(b) Two balls or similar shapes in a vertical line where they can be clearly seen.

The privileges of becoming a NUC reduce the risk of collision; a NUC creates clear precedence and avoids ambiguity for conventional practicing vessels, as stated by Rule 18, which dictates:

i. A power-driven vessel underway shall keep out of the way of: A vessel not under command.
ii. A sailing vessel underway shall keep out of the way of: A vessel not under command.
iii. A vessel engaged in fishing when underway shall, so far as possible, keep out of the way of: A vessel not under command.

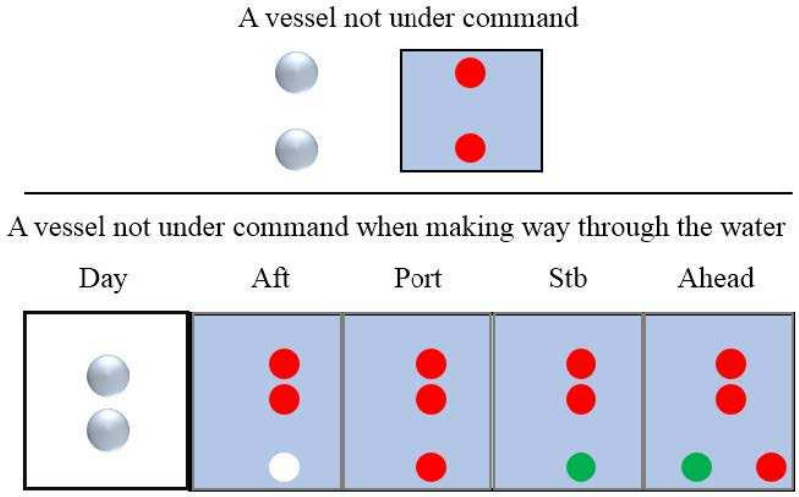

Figure 1. Vessel not under command navigational lights [2].

The proposed practice for NUC vessels comes under scrutiny when regarding inland waterways, narrow channels, and coastal areas. These arguments could be disputed if, as stated previously, ships only practice under degree four of autonomy once the pilot has been dropped off, indicating that once within coastal cruising areas, the ship will operate under either degree two or three of autonomy. This resolution consequently reduces the likelihood of impeding a vessel constrained by draft, as detailed by Rule 18:

i. Any vessel other than a vessel not under command or a vessel restricted in her ability to maneuver shall, if the circumstances of the case admit, avoid impeding the safe passage of a vessel constrained by her draught, exhibiting the signals in Rule 28.

A MASS cruising in coastal waters would be identified as an autonomous vessel by the required day shapes/lights and as indicated by ECDIS and AIS (as per current customary practices with commercial ships), yet would operate under the specifics of a power-driven vessel and follow the collision regulations as required by all vessels operating under the power-driven standard; it would no longer be a NUC. When at two to three degrees of automation, the ship would maintain the operation of Rule 7 Risk of collision, Rule 8 Action to avoid collision, and Rules 13 to 17 in various types of collision situations. Amid the technological advancements expected of the MASS, they would be able to maintain a full appraisal of the situation and use all available means to avoid a collision, as demonstrated by MAXCMAS.

The fundamental issue in identifying a MASS as a NUC is found in current case law. The Navios Enterprise v The Puritan concluded that a vessel not under command is one that has encountered or fallen victim to the engine, steering, or other mechanical failures that impede the safe passage and control of the vessel; the technical limitations of the vessel would be brought forward to avoid a collision. The primary issue arises from the statement, showing that with the current understanding of a vessel not under command, all autonomous ships operating under the banner will be regarded as unseaworthy [10]. The secondary issue is whether precedence is going to be provided to machines over humans, which subsequently poses a moral question that needs to be addressed [27].

An additional scenario in which a MASS may operate is with the privileges of a vessel Restricted in Ability to Manoeuvre (RAM), which would require all other vessels, except

NUCs, to give way. By adopting the same proposed principle as previously discussed with NUC, the MASS would be acquiring the privileges of remaining the stand-on vessel in almost all vessel encounters; this, in turn, would relieve any ambiguity for the manned vessel, as their primary obligation is to stay clear and not impede the passage of the RAM MASS. However, the justification of a ship being regarded as RAM would largely depend on the degree of autonomy under which the craft operates and the nature of the work being conducted (ibid). RAM is notably applicable when referring to Rule 3 COLREGS. The rule specifies the criteria by which a vessel can be considered RAM, such as dredging, towing, or launching and recovery of aircraft [13]. However, the likelihood of MASS performing with such privilege is low, due to the purpose for which they are being created; they are intended to operate to an equal, if not better, standard as that of manned vessels [29]. The promotion of a RAM MASS would be somewhat counterintuitive and potentially damage the reputation of the MASS by illustrating that they do not have the capability of operating to the same degree as a manned vessel. This would suggest that the introduction of MASS is providing little benefit to the services currently in practice on the high seas.

7. Conclusions

The proposed introduction of autonomous vessels has shown practical benefits but has also raised theoretical questions for concern. There are significant legislative and regulatory boundaries that must be overcome before any further development can occur. The lack of singular definitions for ships and vessels limits the chances of flag-registered MASS practicing in foreign waters due to the varying definitions adopted by different jurisdictions. This signifies the first and most overreaching predicament faced by this proposed introduction. The nature in which most of the legislation has been written is with due regard for the human element. Both SOLAS and STCW are built upon the principles of the 'seafarer', and as a result, have created the minimum manning requirements for each size and type of vessel and further detailed the duties of the 'master' in rendering assistance to a distressed vessel.

The thought of MASS experiencing a smooth transition into the current criteria of COLREGS is an implausible prospect. It is extremely unlikely a MASS will be granted the privilege of transiting under the protection of Not Under Command or even Restricted in Ability to Manoeuvre. Cruising under either status would send an underlying message MASS vessels are not as capable, efficient, or as safe as manned ships. The only form in which their existence may be tolerated is if they can adhere to current collision regulations and follow all stand-on and give-way procedures as any trading vessel or ship would do.

If MASS can indicate the ability to adhere to current collision regulations, there will then be a requirement of the IMO to reword and reshape the COLREGS as we know them. With consideration to the administrative resources required to reshape a system that has been deeply embedded in transport for decades, it is unlikely to expect the IMO or other legislative bodies to take any proactive steps, especially as their focus remains on making changes in the marine industry so that it can be regarded as sustainable. The argument of cost-effectiveness for shipowners in terms of reducing costs in crew wages and crew accommodation is a bold one, as shipowners would have to consider the cost of purchasing an autonomous navigation system, constant monitoring, maintenance, security firewall, and general upkeep.

The concluding argument is positive in support of modernising the maritime industry, bringing it alongside other autonomous industries around the world. However, the multi-jurisdictional nature of the marine industry makes it extremely unlikely that any action will take place in the international trading system anytime soon. Furthermore, there are large unanswered questions as to why autonomous movement needs to happen. Manned ships effectively function every hour of the day, ensuring cargo arrives at thousands of ports around the world. The maritime industry is already the most efficient and cost-effective mode of transport for large cargo, and the system need not be disrupted to ensure significant long-term savings.

There are additional questions that need to be clarified regarding how autonomous vessels will practice, including what impact they are going to have on the maritime industry, focusing on the role of the seafarer. The practical implications of the study arise from the speculative nature of available research, with few organisations conducting physical experiments. The concept of autonomous shipping requires heavily investing into further situational experiments to provide a true indication of what the future may provide. The MAXCMAS project has already offered insight into the potential of MASS, but more investigation is required.

Although this research makes a significant contribution to existing knowledge, there were also several limitations in this study, and future work will need to improve in these areas. First, as the starting point for this study, the literature relating to collision avoidance between traditional and autonomous ships was very limited. The theoretical basis was therefore lacking for autonomous vessels. Secondly, the research was limited in terms of time and financial resources. The pandemic restrictions created more challenges for data collection, so only a limited number of Chinese stakeholders were contacted for semi-structured interviews. A longer period to interview various stakeholders could have generated a more in-depth inquiry.

As a result, there is a need for further study on the interaction between autonomous vessels and how they may avoid a collision, including what rules would need to be adopted. Furthermore, there is a question of the integral security of autonomous shipping in deterring security threats and data breaches and what solutions would need to arise over the traditional role of the master when there is no human element on board. Many of these questions will need to be addressed through exploratory accounts in future research.

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Notes

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833109/MSN1868.pdf, accessed on 1 October 2022.

[2] http://cgate.co.il/eng/rules/derech6.htm, accessed on 1 October 2022.

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