TRANSNAV
http://www.transnav.eu
the International Journal
on Marine Navigation
and Safety of Sea Transportation
Volume 18
Number 3
September 2024
DOI: 10.12716/1001.18.03.11

Challenges and Solutions to COLREGs on MASS Ethical Issues in Vessel Manoeuvring Practices

L. He
Shanghai Maritime University, Shanghai, China

ABSTRACT: Though much attention has been paid to the navigational safety of MASS, very few have examined the major challenges that MASS presents to COLREGs from the standpoint of practical vessel manoeuvring. The introduction of MASS may alter the traditional paradigm of vessels depending on seamen for vessel manoeuvring. COLREGs safeguard the orderly statutory nature of vessel navigation. This paper discussed the proper understanding of COLREGs and the ethical MASS issues that can arise from vessel manoeuvring practices in restricted and heavy waters in coastal ports, challenging "look-out," "good seamanship," and navigational safety in COLREGs. The paper also discusses the feasibility of modifying COLREGs and how to solve these problems without modifying COLREGs. The paper suggests expanding the pilotage distances and applying the legal system of maritime traffic management in an integrated manner so as to ensure the safety of MASS navigation in the restricted waters of coastal ports and in heavy waters from the perspective of pilotage and the legal system. This paper suggests that it would be prudent for the IMO not to apply COLREGs directly to MASS until the navigational safety of MASS has been fully considered.

1 INTRODUCTION

Artificial intelligence is gradually infiltrating human life and challenging traditional human paradigms in a variety of industries, including transportation [33]. Vessel navigational aids have been upgraded, such as vessel positioning, which has changed from the old sextant astronomical positioning to GPS, DGPS, and radar object positioning [27]. However, the sextant is still on board the vessel in case of emergency, in case the electronic positioning equipment unexpectedly malfunctions while the vessel is traveling across oceans. Although traditional vessel manoeuvring is controlled by humans, it is gradually undergoing a transformation. MASS is a prominent concept that could reshape the current maritime market [43].

The International Maritime Organization (IMO) started defining MASS in 2017 in response to the fast growth of MASS and divided it into four levels of autonomy: crewed vessel with automated processes and decision support (Degree One); remotely controlled vessel with seafarers on board (Degree Two); remotely controlled vessel without seafarers on board (Degree Three); and fully autonomous vessel (Degree Four) [16]. But before MASS achieves complete autonomy, there are still major obstacles to overcome. One of the major challenges is the development of a safe collision avoidance system that is able to comply with traffic regulations while also safely navigating the sea with other MASS and traditional vessels [1]. The Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs) refers to the set of navigational regulations that ensure safety and order at sea, and

the IMO is responsible for formulating modifications to these regulations. MASS navigation has become more and more common in various countries, and complex legal and safety issues have arisen as to whether or not the rules of the COLREGs apply to MASS. This is particularly true for remotely operated vessels without crew (Degree 3) and fully autonomous vessels (Degree 4). This paper will therefore focus on the application of the understanding of COLREGs in relation to Degree 3 and Degree 4 MASS and the challenges of navigational safety.

The issue is a contentious matter to determine whether the COLREGs' "good seamanship" and "look-out" rules directly apply to MASS. Most academics agree that MASS can meet COLREG's "look-out" requirements through technological means [9]. Considering that the COLREGs apply to "vessels" rather than "masters or crews," it appears that "good seamanship" requirements can be met [20]. Some academics are concerned that technological improvements have the potential to replace some of the capabilities of humans, particularly in situational awareness. Nonetheless, concerns persist regarding sensors' capacity to outperform the human eye and ear in terms of perception in order to offer a thorough evaluation of situational and collision risk [25]. According to recent research, it has been found that many academics are interpreting a term or a separate clause in the COLREGs and have not interpreted the rules from the technical point of view of vessel manoeuvring practice, nor have they considered that the MASS involves the issue of intelligent ethics and the challenge of intelligent ethics to the COLREGs.

With these considerations in mind, the main objective of this paper is to examine the difficulties that arise when examining the application of COLREGs from the technical standpoint of manoeuvring practices for MASS vessels. Additionally, this paper offers both operational and legal solutions to address these issues. The format of the paper is as follows: In Section 2, the main challenges posed by vessel manoeuvring practices with regard to navigational safety and intelligent ethical issues are analysed, along with the understanding of ship manoeuvring practices with respect to the "look-out" rules and "good seamanship" of the COLREGs. Section 3 explores various approaches and presents potential operational options in the future. The discussion is concluded, and recommendations are given in Section 4.

2 EXPLORING COLREGS AND ETHICAL CONCERNS WITH MASS

According to statistics, human factors are involved in 80.7% of marine incidents and collisions [12]. Nonetheless, human error is likely to occur in MASS at degrees 2 and 3, when the impact of the human component will grow [19]. Meanwhile, remote operators working ashore, who are unable to directly observe their surroundings, have less confidence in the physical constraints and limited visibility that can diminish the remote operator's ability to make correct judgments [14]. And MASS has the greatest risk of navigation and chance of accidents caused by machine breakdown when sailing at sea [7]. On Degree 3 and Degree 4 MASS, there will be no crew on board to repair traditional machinery problems should they occur. Losses will increase in the event of vessel collisions, vessel groundings, fires, and explosions due to traditional machinery problems, and even more so in the event of flooding [40]. The next section researches the challenges faced by MASS in applying COLREGs to vessel manoeuvring practices from three perspectives: (1) MASS's understanding of COLREGs in vessel manoeuvring practices; (2) the intelligent ethical issues that may arise for MASS in vessel manoeuvring practices; and (3) MASS's intelligent ethical challenges to COLREGs.

2.1 *MASS's understanding of COLREGs in vessel manoeuvring practices*

Although vessels like the Yara Birkeland [35] may serve as a powerful indication for a shift in the shipbuilding industry, their design is better suited for coastal port waters [23]. However, more than 50 percent of vessel safety accidents occur in coastal port waters [12]. At the same time, MASS has the highest navigational risk of vessel collisions when navigating in coastal port waters [7]. Especially in the case of alternating humans and intelligents in MASS (Degree 3), the risk of negative consequences is increased [37]. Then, MASS needs to pay more attention to navigational safety in coastal port waters and follow the "ordinary practice of seamen" to fulfil the COLREGs to ensure the safety of the vessel's navigation.

The direct reference for the navigational safety of MASS is the traditional vessel. If MASS is to be used as a replacement for traditional vessels, the navigational safety requirements for MASS are higher than those for traditional vessels [32], and the minimum requirements should also be as safe as for traditional vessels [36]. Any collision avoidance and preventive measures that can be achieved by traditional vessels in vessel manoeuvring practice should also be achieved by MASS. The design of the vessel should also be consistent with the navigational safety requirements of traditional vessels. In response to the discussion of MASS navigational safety issues, many academics have emerged from the collision avoidance algorithms for MASS [3] [5] [38], MASS applies to the provisions on flag state jurisdiction and COLREGs in UNCLOS [9] [20], MASS security issues [26], and the cybersecurity issues of MASS [29]. However, few academics have discussed the application of MASS to COLREGs from the perspective of MASS vessel manoeuvring practices.

Why discuss it from the perspective of vessel manoeuvring practices? The reason is that COLREGs involve both legal and technical issues of vessel manoeuvring practices. Therefore, the interpretation of COLREGs should be interpreted from the perspective of legal norms as well as from the perspective of technical norms of vessel manoeuvring practices. When interpreting COLREGs from the perspective of legal norms, it is necessary to strictly follow the concepts, meanings, logics, and contextual links stipulated in the rules to interpret the terms;

when interpreting COLREGs from the perspective of technical norms of vessel manoeuvring practice, it is necessary to follow the natural laws of collision avoidance (such as the geometric principle of collision avoidance) and the "good seamanship" summed up by the seamen based on many years of practical experience to interpret the specific collision avoidance principles and avoidance actions [34]. At the same time, legal interpretations and technical specifications of vessel manoeuvring practices cannot be distinctly separated or confused [41].

Example: COLREGs 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 condition so as to make a full appraisal of the situation and of the risk collision.

Some academics are of the view that, from the point of view of legal interpretation, the above-mentioned rule on "look-out" only mentions "every vessel" and does not explicitly state that the responsibility of lookout is the responsibility of "the master and crew" [20]. Thus, COLREGs seem to be applicable to MASS. However, the requirement to maintain a regular lookout is reflected in "good seamanship" in the Convention on the International Regulations for Preventing Collisions at Sea, 1960, and earlier regulations. This states that it does not exempt the master or crew from liability for the consequences of any negligence in maintaining a regular lookout [34]. Thus, the master or crew is assigned lookout duty under the COLREGs. Simultaneously, the term "vessel" in this rule can be interpreted, from a prudent and reasonable standpoint, to mean not only the objectivity of the "vessel" itself but also all available seamen on board, navigational aids, as well as any appurtenances and installations on board, and any manner and means.

From the point of view of vessel manoeuvring practice, the lookout approach is one in which all effective means can be employed with the aim of continuously monitoring nearby vessels. In vessel manoeuvring practice, the officer on watch (OOW) maintains an uninterrupted lookout because the seaman is required to determine in real time the dynamics of any of the surrounding vessels, even if they are only at potential risk of collision with the vessel or are not at risk of collision for the time being. In the practice of vessel manoeuvring, vessel "A," which is not in danger of collision with our vessel, vessel "A," may take measures to adjust its course or speed to avoid collision with vessel "B," whereas vessel "A," which has adjusted its course and speed, may be at risk of collision with our vessel. Therefore, from the perspective of vessel manoeuvring practice, it is important to pay attention not only to the simple head-on situations of crossing and overtaking but also to the motion situations of all the vessels around our vessel.

In heavy coastal waters, a vessel may need to consider collision avoidance with more than one vessel at a time. However, if one of these vessels changes course or speed, the OOWs will need to immediately assess the new situation and make a new avoidance strategy. As well, when the vessel is sailing in restricted waters or has poor visibility in a coastal harbour, the master will assign the bosun to the bow to assist the OOWs in keeping a lookout and preparing to drop the anchor. The two most basic ways to keep lookout are usually with the naked eye and radar. The use of naked-eye observation can be seriously affected in conditions of low visibility, and there are inherent defects in radar, including the inherent "blind zone" defects of radar, and the fact that wind, waves, rain, and snow can interfere with the use of radar or make it unusable when it is interfered with by other military equipment in coastal areas. Therefore, there may be errors in the radar-scanned echoes, and sometimes the radar-scanned object echoes are difficult to use as collision avoidance by vessels, which requires the experience of the OOWs to judge them. Additionally, the weather at sea is changeable, so in order to enable OOWs to have a clearer lookout, wipers and glass heating appliances will be added to the glass of the vessel's bridge. Furthermore, in the actual navigation of the vessel, radar interference and poor visibility may occur at the same time. In this situation, the vessel cannot immediately stop and drop anchor to wait for the weather to clear, as the actual depth of the sea and the restricted area do not allow dropping anchor. After that, the master will continue to command the vessel on the bridge with his physical perception of the environment as well as his extensive navigational experience. Nevertheless, MASS (Degree 3) shore-based remote operators are not able to be in a real environment or be aware of their environment. It is also important to consider the navigational aids and auxiliary appliances required in vessel manoeuvring practices to cope with the various special weather conditions at sea. MASS (Class 3) should not be considered to be directly applicable to COLREGs if MASS cannot fulfil the minimum requirements for traditional vessels.

As mentioned in this paper, OOWs require monitoring the motion situation of the nearby vessels uninterruptedly, as it is necessary to assess the intention of other vessels to change their motion situation, which is also the basis for subsequent reasonable collision avoidance measures. In the case of MASS (Level 3) man-machine coexistence, if intelligence is involved in the pre-collision avoidance measures or during the collision avoidance measures, the transition between man and machine requires a long period of time to judge and measure the avoidance situation, which is a serious threat to navigational safety and should not be regarded as a full, uninterrupted, real-time performance of lookout duties. Because COLREGs are both technical and legal norms, it takes collaborative research by experts in both maritime law and nautical technology to achieve the natural unity of the two [26]. Therefore, the applicability of MASS to COLREGs cannot be judged and interpreted solely from the legal point of view but also from the technical point of view of navigational practice.

2.2 *Intelligent Ethical Dilemmas of MASS in Manoeuvring Practice*

The IMO defines MASS (Degree 4) as a fully autonomous, intelligent vessel [16]. An artificial intelligence application needs to take into account its

operating environment in order to function properly [28]. In coastal harbour-restricted waters, the width of the channel becomes narrower, the depth of water becomes shallower, and the distance from the shore of the vessel becomes closer. As a result of these conditions, the speed of the vessel also needs to be higher, because a reduction in speed affects the rudder effect or even leads to the disappearance of the rudder effect [39]. The vessel sails in a narrow channel, its manoeuvrability is somewhat restricted, and it cannot steady course if the rudder effect diminishes or fails [8]. Vessel collisions frequently occur in narrow channels due to certain characteristics, such as variable width, water depth, and heavy waters in coastal ports. This severely hinders the development of marine transportation [13] [21]. When both channels are crowded and there is a high vessel density in the narrow channel along the coast, there is very little chance that a vessel will alter its course [15].

In coastal harbours, there are often many small vessels in narrow channels, and often it is impossible to determine whether these vessels are fishing (Rule 3(d): The term "vessel engaged in fishing" means any vessel fishing with nets, lines, trawls, or other fishing apparatus that restricts manoeuvrability, but does not include a vessel fishing with trolling lines or other fishing apparatus that does not restrict manoeuvrability), as well as fishing vessels made of wood. Furthermore, a significant risk to MASS is posed by these wooden fishing vessels with small object markers, weak radar echoes, small vessels with poor communications, and fishing vessels that are unable to recognize the proper action [6]. Because most small coastal vessels do not understand or pay attention to COLREGs and information communication, it is challenging to use collision avoidance prediction models or algorithms for collision avoidance actions. This makes it difficult for large cargo vessels to coordinate avoidance with them, and it also results from the unstable course and speed of small vessels. Small fishing vessels are unfocused and prone to abrupt course changes, abrupt accelerations, abrupt decelerations, and abrupt stops. If OOWs want to "departure from these rules" and avoid the "immediate danger" as defined by the COLREGs, they must therefore pay attention, avoid collisions as soon as possible, and act quickly to confirm and communicate with other large cargo vessels in the area.

Furthermore, systems that deploy artificial intelligence in the field will eventually have to make a decision between two potentially undesirable outcomes [28]. For example, (1) when a collision between MASS and either of the other two vessels is unavoidable, MASS needs to make a choice of which vessel to collide with; (2) if MASS is restricted from manoeuvring in restricted waters in narrow channels along the coast, for example, when encountering small vessels in narrow channels that do not comply with COLREGs, fishing vessels that do not recognize the correct action, or wooden fishing vessels that do not have the ability to communicate information, MASS has to make a choice of whether it will keep its speed and its course, or will it steer out of the way.

In response to the above situation of MASS choosing between two potentially unfavourable outcomes, this paper proposes the following questionnaire for seamen in the unlimited area of navigation with different duty, vessel types, and backgrounds:

Table 1. Basic information about the questionnaire respondents)

Category	Subcate-gory	Quan-tities	Other Careers	Vessel Type
A	A1	5	-	oil and chemical
(Master)	A2	1	maritime superintendent	oil and chemical
	A3	2	-	bulk and container
	A4	1	university professor	bulk and container
	A5	1	Ph.D. and maritime lawyer	bulk and container
B	B1	3	-	oil and chemical
(Chief Mate)	B2	2	-	bulk and container
C	C1	5	-	oil and chemical
(Second or Third mate)	C2	5	-	bulk and container
D	D-B2	1	pilot I	oil and chemical
(Pilot)	D-C2	1	pilot II	bulk and container
E	E-C1	1	maritime lawyer	oil and chemical
(Maritime lawyer)	E-C2	1	maritime lawyer	bulk and container
F	F-C1	1	MSA official	oil and chemical
(MSA)	F-C2	1	MSA official	bulk and container

The respondents in Table 1 gave different answers from their own backgrounds, as follows:

Table 2. Different backgrounds lead to different choices of collision avoidance measures

Category	Possible measures for collision avoidance
A1	For instance, in extremely harsh circumstances, a VLCC (Very Large Cargo Carrier—Crude Oil Tanker) master will ram any vessel that gets in the way with great directness. Additionally, the master clarified that a fully loaded VLCC can carry up to 300,000 tons of cargo oil, that the draft may exceed 21 meters, and that the vessel's manoeuvrability is very poor, making it difficult to steady course and slow down speed in order to avoid the vessel. There is a chance that oil will spill if it runs aground.
A2	Make the avoidance limit comprehensively based on the vessel type's characteristics, report to VTS for coordination, make full use of the vessel's manoeuvring limits, pass as close to the obstructing vessel as possible, and avoid using a large rudder angle in the last stage of avoidance. Either the anchor is used before going aground, or the engines and rudders cooperate. If there is only an extreme choice, the choice will be to avoid the obstructing vessel, and human life will be the first priority.
A3	Evaluate the limits of the vessel's manoeuvring and, if only extreme choices are available, will not choose to run aground and will keep the vessel's speed to a minimum to minimize the damage caused by a collision.
A4	If only extreme choices can be made, actively choose to run aground, with human life being the priority.
A5	It's hard to answer, and it's a test not of vessel manoeuvring skills but of human nature.
B1 and B2	Questionnaires were sent to a total of five people, four of whom did not respond. Another considered that, if left with an extreme choice, it would be preferable to run aground rather than to injure human lives.
C1 and C2	The answer is pretty much unanimous: comply with the COLREGs and prefer to run aground rather than collide with the vessel.
D-B2 and D-C2	Reduce the vessel's speed to the minimum speed that can be maneuvered, and drop anchor if necessary. At the same time, contact VTS for assistance and send tugs and pilot boats to drive away the obstructing vessel.
E-C1	Comply with COLREGs and reduce the speed of the vessel, but reducing the speed dramatically in a narrow channel does not seem to be "good seamanship." However, in any event, even a collision cannot be deemed to be subjectively intentional or reckless, as this would

	affect the application of the "exemption from liability" provisions of the Maritime Law.
E-C2	Even though the waters of the narrow channel are restricted and such situations have been encountered before, he is confident that he can pass through safely. At the same time, it was felt that it took courage to navigate the vessel to avoid the collision and that it was necessary to be both careful and courageous.
F-C1 and F-C2	The master was immediately called to the bridge, and until the master had clearly handed over command, collision avoidance measures would be strictly enforced. At the same time, it was considered that the consequences of a collision could lead to the sinking of the obstructing vessel or casualties, which could be more serious than a grounding.

Based on the information from the questionnaires in Tables 1 and 2 above, it can be seen that phenomena such as virtue, humanity, courage, subjectivity, value judgments, and different types of vessels leading to different ways of manoeuvring are likely to be involved in extreme vessel manoeuvring for collision avoidance. Realizing virtue in artificial intelligence applications is inherently challenging. For example, how do you quantify a brave algorithm through a rule-based approach? One view that contrasts with virtue is the utilitarian view, which holds that ethical decisions maximize value [10]. Assuming that MASS can be as fully autonomous as humans and has the ability to learn on its own, what choice will MASS make in the face of the possibility of causing danger to human lives or causing significant environmental pollution and economic loss? In this way, the intelligent ethical dilemma of MASS arises.

2.3 *The MASS Intelligence Ethical Dilemma for COLREGs*

Moral decision-making cannot be explained solely through moral dilemmas but is a situation-dependent process of autonomous agent behaviour [2]. The navigational environment of MASS in narrow coastal channels is more complex and scenario-variable than that of self-driving cars. Some academics have already researched the moral impact of self-driving cars in terms of the perception that self-driving car algorithms will ultimately have to make decisions that negatively impact passengers or other road users and that moral judgments about this decision will have implications for both self-driving car algorithms and policy implementation [11] [18]. Then, the decisions MASS makes when faced with intelligent ethical dilemmas will also pose a challenge to COLREGs.

According to Rule 18 of the COLREGs, "Responsibility between vessels," the motor vessel shall give way to the vessel engaged in fishing. Under rule 9 of the COLREGs, "narrow channels," a vessel engaged in fishing shall not impede the passage of any other vessel navigating within a narrow channel or fairway. It follows that a vessel engaged in fishing should not impede a MASS navigating in a narrow channel or fairway, and the emphasis here is only on "should not impede," without altering the duty to give way to the motoring vessel normally navigating in a narrow channel.

If COLREGs apply to MASS, MASS is still responsible for giving way to fishing vessels. As a general guideline, an attempt should be made to achieve a DCPA (distance closest point of approach) of 2 nautical miles on the high seas and 1 nautical mile on restricted waters [22]. A channel of 2 nautical miles in width is usually regarded as a narrow channel [34]. And within the narrow channel, it is difficult for MASS to choose to pass at the safest meeting distance (1 nautical mile). If the MASS turns at a large degree of course or reduces speed significantly to avoid an obstructing vessel or a vessel with a risk of collision in restricted waters, does the MASS need to take into account the grounding factor? If MASS considers the grounding or reefing factor, does MASS have the courage and confidence to pass close to obstructing fishing vessels? And if MASS is brave and courageous, then MASS has a courageous "risk-taking" attitude towards the possibility of collisions that could result in injury or death?

Does a MASS have to follow the COLREGs by changing course or reducing speed to avoid a collision if a small vessel, a fishing vessel that is incapable of recognizing the proper action, a wooden fishing vessel that is unable to communicate, etc., not only obstructs the MASS while it is navigating normally in a narrow channel but also creates a risk of collision? This is because the goal of the COLREGs is to prevent vessel collisions. Is the MASS obligated to comply with COLREGs by changing course or reducing speed to avoid collisions, given that the goal of COLREGs is to prevent vessel collisions? But MASS may seriously harm the environment or result in economic damage if it conforms with the COLREGs; if not, it violates the regulations and runs the risk of causing vessel accidents that threaten human life.

In summary, the challenges facing COLREGs are: (1) When presented with a decision between perhaps inflicting considerable property damage and potentially endangering human life, how should MASS make it? (2) The understanding and application of COLREGs vary from person to person and context to context, so there may be a judgment of subjective thinking in their application. So how can the subjective thoughts of MASS be judged?

3 RESULTS AND DISCUSSION

The navigational safety of MASS is largely based on assumptions about the applicability of COLREGs. The need for MASS to fulfil all the technical requirements and devices of traditional vessel manoeuvring practices and the ethical dilemmas of MASS may seriously hamper the development of this new technology. COLREGs are not set in stone but are a living instrument. MASS can apply to COLREGs only if they satisfy the requirements of the same performance as traditional vessel manoeuvring and if they resolve ethical dilemmas. In order to promote MASS operations and navigational safety, the following issues will be discussed: (1) Is it feasible to revise the COLREGs? (2) Is it feasible to expand the pilotage distances in conjunction with marine traffic management?

3.1 *Revision of the feasibility of COLREGs*

The "look-out" rule of the COLREGs has attracted much attention, and some academics have suggested that it should be amended to allow look-out by "computer vision" only [44]. However, the COLREGs regulations are intrinsically related to each other and do not stand alone. The COLREGs should be viewed as a whole and should not be discussed in isolation. It should not be assumed that once MASS fulfils the requirements of a certain regulation, it can be directly concluded that MASS can apply COLREGs in a comprehensive manner.

COLREGs Rule 2 (a): ordinary practice seamen: There is no rigidity of text as to what the usual practice of seamen means; it is a question of ascertaining its facts in the light of all the relevant circumstances [24]. Furthermore, good seamanship means good practice, while ordinary practice seamen means general practice and alludes to good general practice [34]. Therefore, such precautions as may be required by the ordinary practice of seamen or by the peculiar circumstances of the time are basically regarded as an expression of good seamanship. So, "ordinary practice seamen" is correlated with "good seamanship." COLREGs rule 5 "look-out": Seamen, in carrying out their lookout duties, should apply all information obtained from the lookout to the vessel's collision avoidance using good seamanship. So, "look-out" is correlated with "good seamanship." The "safe speed" rule referred to in Rule 6 of the COLREGs: Safe speed needs to be based on the navigational environment and navigational waters of the formal lookout. The formal lookout includes the density of vessels in the nearby sea area, visibility, wind and wave flow conditions, other vessel encounter situations, and so on. After a comprehensive judgment of the adoption of a safe speed, the lookout is also a means of judging whether there is a risk of collision with other vessels. So, "look-out" is correlated with "safe speed." The "risk of collision" rule referred to in Rule 7 of the COLREGs: The reference to radar and radar plotting in paragraph (b) of this article is to the navigational aids and collision avoidance calculations contained in the "look-out" rule, and in the process of collision avoidance calculations, a safe speed is to be used. In vessel manoeuvring practice, most vessels sail at a constant speed in order to allow the other vessel to measure TCPA and DCPA and to use good seamanship to avoid the "close-quarters situation" in COLREGs Rule 8. The COLREGs Rule 2 (b) "departure from these rules" to avoid "immediate danger" is often faced in restricted waters with dense traffic in coastal ports. This is because in congested waters with vessel traffic, such as harbours and narrow channels, where multiple vessels can meet and pose a danger of collision, there are special circumstances in which deviations from the rules may be made. Similarly, "ordinary practice of seamen" requires the application of "good seamanship" and conforms to "ordinary practice of seamen in special circumstances."

In summary, the "look-out" rules can essentially establish a direct or indirect link with any other rules. There is also an intrinsic link between the various rules of the COLREGs. The discussion of the COLREGs' rules cannot be analysed separately. If MASS applies COLREGs, then any of the requirements of the COLREGs should be applied without any conflict, and MASS needs to meet the same navigational safety capabilities, conditions, facilities, and appliances as a traditional vessel. If the COLREGs are revised, the conflict between and the application of MASS to any of the COLREGs' rules will need to be considered. Avoiding conflicts of understanding or difficulties of application between traditional vessels and MASS. This is because these conflicts of application may increase the number of marine traffic accidents in the restricted waters of coastal ports.

3.2 *Maritime traffic management in conjunction with extended pilotage distances*

Maritime traffic management can be categorized into VTS (Vessel Traffic Service), Vessel Reporting System, and Vessel Routing System [17]. International Convention for the Safety of Life at Sea (SOLAS) regulations V/11(1) and V/12(1) provide that the objectives of both vessel reporting and VTS are to assist vessels in their efforts to ensure the safety of life at sea, the safety and efficiency of navigation, and the protection of the marine environment. Under regulation 12(2) of the SOLAS, states have the right to establish VTS when they consider that the volume of traffic or the level of risk warrants the provision of such services, and the IMO Guidelines and Principles on Vessel Reporting and VTS imply that these systems are to be applied by the "seamen" or the "master" [4] [32]. At the same time, under SOLAS regulation V/10, the coastal state has the right to impose a mandatory vessel routing regime on foreign vessels, and there is a correlation between the TSS and COLREGs rule 10 traffic separation scheme. Then, in order to address the possible ethical challenges and navigational safety of MASS without modifying the COLREGs, it would be more appropriate for MASS to be piloted by human beings in coastal harbour waters. From the previous questionnaire survey, it can be seen that the measures available to the pilot to avoid vessel collisions are the most numerous and relatively adequate, and he can always deploy tugs, pilot boats, and all the means of the maritime traffic management system to avoid the occurrence of accidents, so the extension of the pilotage distance is a more appropriate option. COLREGS could not be successfully used to regulate traffic flow, so another solution was needed. This solution takes the form of TSSs in areas with high concentrations of traffic [30]. The specific location of the pilotage station and the specific pilotage distance can be set by each country through a comprehensive assessment of the traffic density and the frequency of traffic accidents. If a traffic accident occurs in the course of piloting, the issue of liability between the pilot and MASS can also be determined in accordance with each country's domestic pilotage-related laws.

4 CONCLUSION

The continued development of MASS in commercial operations requires compliance with COLREGs for navigational safety, but it faces challenges: (1) The

question of whether MASS satisfies the application of COLREGs in vessel manoeuvring practice; (2) MASS may present an ethical question of choosing between a threat to human life or a major environmental contamination or damage to property.

According to the research mentioned earlier in this paper, the MASS shall satisfy all means of collision avoidance and appurtenances that are consistent with traditional vessel manoeuvring practices to ensure that the MASS is applicable to COLREGs. At the same time, a questionnaire survey was conducted among respondents of different backgrounds and ranks. It is concluded: (1) The attitude of the master of a large dangerous goods vessel, in extreme and unavoidable circumstances, is to prefer a collision to running the vessel aground, even though a vessel collision will probably result in loss of life or injury; (2) The attitude of masters of general cargo and container vessels, in extreme and unavoidable circumstances, is to reduce speed as much as possible, slowing down with an anchor if necessary, to minimize collisions and to reduce damage; (3) The chief, second, and third mates, usually choosing human life first, will actively choose to run aground; (4) The pilot's attitude is to use the vessel's manoeuvring to the utmost and to cooperate with all measures, such as anchors, VTS, tugs, pilot boats, etc., to drive away obstructing vessels; (5) The maritime lawyer's attitude was that he would not make any choices that might increase his legal liability and that even if a collision might occur, he had not acted deliberately or recklessly because of the exemption from liability in the Maritime Law; (6) The attitude of the officials of the MSA is that they are more concerned with personal injuries and deaths at sea than with marine traffic accidents. Assuming then that MASS is autonomous and capable of self-learning, it will face ethical choices, and artificial intelligence, which is primarily concerned with helping and serving humans, must not be given choices that could harm human life. If MASS does not have enough courage and bravery, then it is likely to increase the rate of marine traffic accidents when sailing in restricted coastal waters.

Due to the dual combination of legal and technical attributes of COLREGs, there are different interpretations and applications of COLREGs in different contexts. Therefore, the application of MASS to COLREGs cannot be judged solely on the basis of the interpretative standards of the law. If the option to revise COLREGs to apply MASS is selected, then the systemic nature of COLREGs should be taken into account to avoid conflicts of understanding and errors of application when used simultaneously with traditional vessels.

Finally, this paper argues that COLREGs are subjective and value-judging, so they are applicable to vessels piloted by human beings, and suggests that the IMO should be prudent in applying COLREGs directly to MASS before comprehensively considering MASS's navigational safety.

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