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# The challenge of safe and sustainable development of the unmanned ship: seeking for effective legal responses

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Technological innovation is changing the way maritime transport is done, and automated driving is one of the hot topics, including unmanned ships that use automated driving technology, but legal challenges to the application of unmanned ships in the shipping industry must be resolved before that happens – whether and how the principles of existing international conventions regarding unmanned ships. To deal with this problem, it is far from enough to rely on the efforts of international organizations or the revision of international conventions. The paper analyzes several typical legal issues faced by unmanned ships: the legal definition of unmanned ships, the seaworthiness of unmanned ships, the master and crew rules, and the collision and rescue of unmanned ships, taking China as an example, the paper explains reasonable and effective legal path of domestic and international laws, trying to seek solutions at the level of domestic law beyond international convention. The paper concludes that the traditional navigation rules have largely been developed to meet the needs of manned transportation, and cannot be fully applied to unmanned ships. Therefore, until there is an international regulation specifically for unmanned ships, it would be appropriate to interpret or revise existing international conventions to apply to unmanned ships. And for countries including China, it is important to consider the improvement of domestic laws.

## KEYWORDS

unmanned ship, shipping, international conventions, laws and regulations, legal responses

## 1 Introduction

In recent decades, technological progress in all sectors of world trade is progressing by leaps and bounds, the shipping industry is no stranger to that progress. Electronic shipping documents, automated ports and terminals, the electronic communications are changing the way shipping is done. Among these, recent advances in sustainability development for

autonomous systems are undoubtedly unmanned ships. Unmanned ships are those which can control movement on the water without any on-board crew. There are two main ways of control: One is done by remote control from shore; the other is done by pre-programming the ship to follow a predetermined nautical course without any human interaction<sup>1</sup>. In 2015, the Comité Maritime International (CMI, 2015) set up an International Working Group (IWG) on unmanned ships, and the IWG submitted a work report that makes clear the definition of the unmanned ship:

*The term “unmanned ship” refers to a ship that has no crew members on board. Depending on the level of automation, the ship may be operated either remotely by one or more shore-based remote controllers, or in a fully automated mode without human intervention. The level of automation of the operation is not fixed but may change during a single voyage.*

At the 100th session of the Maritime Safety Committee (MSC) of the International Maritime Organization, the definition and classification of Maritime Autonomous Surface Ships (MASS) were proposed, marking the progress in the supervision of unmanned ships as shown in Figure 1 (IMO, 2018).

Unmanned ships can be developed both in civil and military fields. The military applications of unmanned ships include port patrol, port mine clearance and demining, anti-terrorism investigation, fire support, etc (Chen et al., 2023). Currently, unmanned ship technology cannot be used for international maritime trade, mainly used as carriers of various measuring equipment, such as hydrology, oceanography and offshore technology (Felski and Zwolak, 2020). Although unmanned merchant ships do not yet exist, they are an emerging area of technology worth considering in recent years (Wahlström et al., 2015). The Maritime Unmanned Navigation through Intelligence in Networks (MUNIN, 2012) project, funded by the European Commission under its Seventh Framework Programme, which is for the development of the “remote controlled operation” unmanned ships. The project has successfully drafted concepts and developed system prototypes. The Advanced Autonomous Waterborne Applications Initiative (AAWA, 2016) is a project funded by the Finnish Funding Agency for Technology and Innovation, combines the expertise of leading academic researchers, including Rolls-Royce, DNV-GL, Inmarsat, etc. They explained the functions of the unmanned ship and planned to apply it in Finnish waters.

As compared to traditional merchant ships, unmanned merchant ships use advanced methods/algorithms, intelligent awareness, data fusion, communication and other advanced technologies to achieve automatic operation, navigation and berthing. In the process of navigation, management, maintenance and transportation of goods, ships can be operated intelligently,

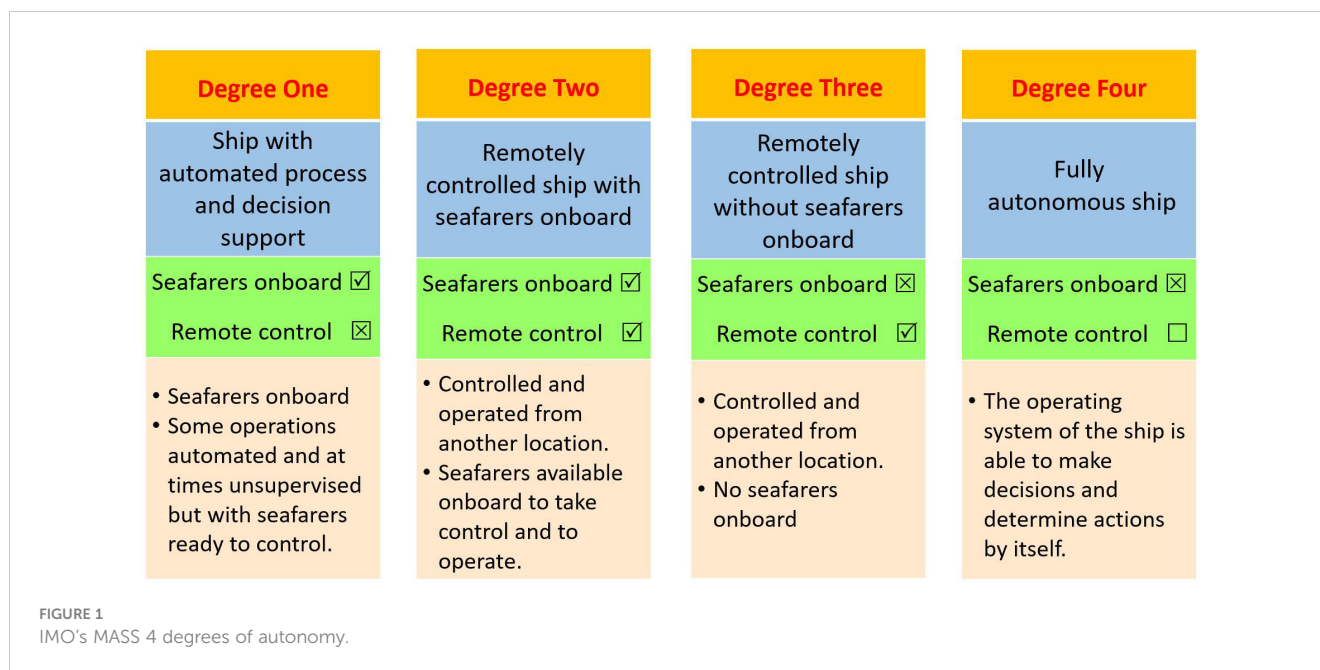
giving ships greater advantages in safety, society and economy (Wang et al., 2020). With the rapid development of technology, several unmanned merchant ships are being developed, the world’s first unmanned commercial shipping operation was successfully conducted (BBC, 2019). There have been many projects aiming at the development of unmanned merchant ships in recent years, such as the MUNIN project, funded by the European Commission under its Seventh Framework Programme, which is for the development of the “remote controlled operation” unmanned ships. The project has successfully drafted concepts and developed system prototypes (MUNIN, 2012). It is believed that more unmanned ships for international cargo transport will become operational within the near future.

Of course, the ways in which the ships would operate is an unsolved problem (Wahlström et al., 2015), and the safety of unmanned ships is also the focus of academic attention (Felski and Zwolak, 2020). The shipping industry has also reacted, with Lloyds Register (LR, 2017) producing its own “LR Code for Unmanned Marine Systems”, The Det Norske Veritas (DNV, 2019) produces its own class guideline entitled “Autonomous and Remotely Operated Ships”. Both documents provide a detailed framework for safety and operational requirements for unmanned ships.

The prospect of unmanned ships addresses a fundamental feature of shipping – the role of the master and crew on board, and will therefore affect a large number of laws and regulations in the whole area of maritime law (Ringbom and Veal, 2017). In March 2017, the IWG distributed a questionnaire among CMI member associations. The questionnaire is part of the regulatory review undertaken by the IWG to identify the nature and extent of potential obstacles to the introduction (wholly or partly) of unmanned ships in the current international legal framework. More than 20 countries including China, the United States, and the United Kingdom had replied (CMI, 2015). The MSC of the IMO (2021a), at its 103rd session in May 2021, has completed a regulatory scoping exercise to analyze relevant ship safety treaties, to assess how MASS could be regulated. This work involves the assessment of a large number of IMO treaty instruments within the MSC’s remit. At the Maritime Safety Committee (MSC 102) in April 2022, the MSC approved a road map containing a work plan for the development of IMO instruments for MASS and will be developed a mandatory MASS Code which is envisaged to enter into force in 2028 (IMO, 2022).

In fact, IMO has more than 50 effective international shipping regulations and conventions, and the obligations in these rules are reflected in the domestic shipping legislation of each state to be observed and fulfilled. Therefore, each IMO shipping regulation will play an important role in integrating the unmanned ship into the existing regulatory framework. While if the unmanned ship is excluded from the regulatory framework, it will raise concerns. For example, the collision or grounding of an autonomous sailing unmanned ship caused by some third party’s unmanned software problems during navigation may lead to disputes over the liability of the shipowner, the newly introduced liability subject will also change the traditional way of liability bearing. Similarly, for each state, to what extent unmanned ships could navigate in different sea

<sup>1</sup> These definitions are based on the CMI International Working Group Position Paper on Unmanned Ships and the International Regulatory Framework. Here is only a brief expression that is helpful for understanding, without detailed technical analysis. If it is not specifically pointed out, “Unmanned Ships” referred to in the following paper contains these two forms without distinction.



seas; what obligations do states have over unmanned ships flying their flags; and what rights do other countries have to interfere with the navigation of unmanned ships in different waters? Whether these traditional maritime issues could be applied to unmanned ships is of great concern too.

With these concerns, several countries have elaborated proposals regarding unmanned ships while waiting for the international regulatory framework. For example, the Maritime UK has launched the Autonomous Vessel Code of Practice, which covers all aspects of the manufacture, safety, communications, and navigation of unmanned ships, the Code prepared by the UK Maritime Autonomous Systems Working Group, aims to provide guidance on the development of relevant technologies, and a more detailed regulatory framework for the construction of unmanned ships (Maritime UK, 2017). The Danish Maritime Authority released its final report of the Analysis of Regulatory Barriers to the Use of Autonomous Ships in 2017, it analyzed the domestic laws of Denmark, the EU regulations, and the IMO international conventions, and sorted out the regulatory barriers faced by the unmanned ship in the civilian commercial shipping (Danish Maritime Authority, 2017). The report covers issues relating to the jurisdiction, navigation and collision rules, the allocation and crew of the unmanned ships, liability, compensation and insurance issues, etc.

China is a major shipping country. As an important part of the comprehensive transportation system, shipping carries more than 95% of China's global trade transportation. The shipping capacity of China's maritime fleet ranks second in the world, and the transport service network connects major ports of more than 100 countries and regions (Tong, 2022). China's technology of the unmanned ship is also developing rapidly. Early in 2017, an unmanned ship accompanied the Chinese polar research vessel to complete a polar research mission. In 2018, the world's largest and Asia's first unmanned ship testing ground was opened in Zhuhai. In May

2022, the "Zhuhai Cloud" unmanned scientific research ship was launched in Guangzhou, which will be used for ocean scientific observation (GMW, 2022). In September 2022, China's Ministry of Natural Resources, together with several agencies, completed a marine mapping and offshore seabed survey project with the help of five unmanned ships (YUNZHOU, 2021). China attaches great importance to the research and development of unmanned ships. The Rules for Intelligent Ships compiled by the China Classification Society (CCS, 2015) came into effect in 2016, and the CCS also formulated the Guidelines for Autonomous Cargo Ships, standardizing the construction and safety of autonomous unmanned ships (CCS, 2018).

Technological innovations are changing the way maritime transport is done, but legal challenges to the application of unmanned ships in the shipping industry must be resolved before that happens. This is an urgent problem for all countries, including China, not just waiting for an international convention or any international organizations.

## 2 Methods

This paper does not discuss the specific operation and safety of unmanned ships from the technical level but from the legal perspective. Technology research on unmanned ships has been proceeding for decades, but it is only in recent years that the legal and policy issues of unmanned ships have been studied (Van, 2014). Unmanned ships are the most controversial aspect of international law (Zhu and Xing, 2022). The research method adopted in this paper is the classical legal method. They are primarily desktop studies and analyses of major legal resources, including international conventions and several Chinese domestic laws. What exactly is the definition of an unmanned ship? Can existing rules of international laws be used to regulate future unmanned

merchant ships? It should be noted that ships are the core elements of maritime navigation, and the application of unmanned ships may bring huge changes to the whole shipping industry. Therefore, international rules must be fully thought out and responded to, and regulation needs to address the legal issues raised by technological advances (Katsivela, 2018).

This research method is qualitative, carried out through (a) research and description of the existing legislation (b) prescription, and its essence is to explore the legal issues faced by unmanned, and (c) relying on the assessment of international and domestic legislation to draw conclusions (Van Hoecke and Warrington, 1998). Relevant legislation is the primary source of data, and other similar studies are often evaluated to support the author's suggestions and to demonstrate the extent of the problem discussed (Boviatsis and Vlachos, 2022).

## 3 Discussion and Results

### 3.1 Is an unmanned ship a “ship”?

The operating conditions of unmanned ships on the sea largely depend on whether their legal status is “ship” (Veal et al., 2019). The 1982 United Nations Convention on the Law of the Sea (UNCLOS) prescribes detailed provisions on the countries' rights and obligations in respect of their flagged ships (Article 94), and prescribes rules for “devices” and “equipment”, especially in the field of marine scientific research (Part XIII), however, the UNCLOS does not define the scope of the two terms “ship” and “vessel”. Other international conventions, such as the 1972 International Regulation for Preventing Collision at Sea (COLREG) define a ship as “every description of watercraft, including non-displacement craft and seaplanes, used or capable of being used as a means of transportation on water” (Rule 3 (a)). The 1973 International Convention for the Prevention of Pollution from Ships (MARPOL) Article 2 (4) states that “Ship means a vessel of any type whatsoever operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft and fixed or floating platforms.” The 1986 United Nations Convention on Conditions for Registration of Ships defines a ship as “any self-propelled sea-going vessel used in international seaborne trade for the transport of goods, passengers, or both with the exception of vessels of less than 500 gross registered tons.” The “ships” defined by these international conventions fall within the objectives of their particular conventions. If an unmanned ship meets the technical requirements required for a “ship” in these international conventions, it should be considered within the scope of the application of conventions.

It should be noted that if unmanned ships do not fall within the scope of the UNCLOS, they cannot enjoy navigation rights under the convention, ship operators and carriers cannot enjoy corresponding rights and obligations. But it is clear that even unmanned ships should enjoy the same passage rights as other ships, and should not be denied access to other countries' waters merely because they have no crew. Taking the right of innocent passage as an example, based on Article 17 of the UNCLOS, ships of

all States may enjoy the right of innocent passage through the territorial sea. Article 19 of the UNCLOS provides a list of activities prohibited in the territorial sea by the innocent passage of ships, which focuses more on the activities of ships than defining “ships” themselves. Conversely, unmanned ships, which are not defined as “ships”, are unable to navigate their territorial waters without the permission of the coastal State, possibly because they are engaged in activities “prejudicial to the peace, good order or security of the coastal State”. At present, the classification of unmanned ships as “ships” seems to be the general view of academics, as the operation of unmanned ships may involve the same risks as manned ships, which is perhaps one of the most powerful arguments for the need to treat unmanned ships as “ships” and subject them to the UNCLOS regulation (Ringbom and Veal, 2017).

The exception here is Article 29 of the UNCLOS which directly includes the captain and the crew as necessary attributes:

*“Warship” means a ship belonging to the armed forces of a State bearing the external marks distinguishing such ships of its nationality, under the command of an officer duly commissioned by the government of the State and whose name appears in the appropriate service list or its equivalent, and manned by a crew which is under regular armed forces discipline.*

According to this definition, a warship should first be considered as a “ship”, an unmanned ship that does not have the status of a ship should not be considered as a warship, and even an unmanned ship that has the status of a ship cannot belong to a warship, as its features do not meet the necessary conditions for having military officer and crew on board in this article. But it should be noted that due to the combat purpose and specificity, the warship is closer in definition and usage to “weapons” than to “ships”. Since military unmanned ships are closely related to national interests, customary international law has not extended the definition of military ships to military unmanned ships (Chang et al., 2020).

According to Article 91 of the UNCLOS, the definition of the ship is the domain of adjustment of domestic law, the flag states have the right to decide whether an unmanned ship constitutes a ship or not (Veal and Tsimplis, 2019). In the questionnaire issued by the IWG, the first question is about the status of the unmanned ship (CMI, 2018a):

*Would a “cargo ship” in excess of 500 grt, without a master or crew onboard, which is either controlled remotely by radio communication? controlled autonomously by, inter alia, a computerised collision avoidance system, without any human supervision constitute a “ship” under your national merchant shipping law?*

Among the responses received, most countries, including the United States, Canada, Italy, Japan, etc., agreed that an unmanned ship would or most likely would constitute a ship under their national law. Only a very few countries have explicitly denied the status of the unmanned ship as a ship. The United Kingdom, for example, stated in its response that, a ship either remotely controlled or in autonomous operation may not fall within the definition of “ship” in its Merchant Shipping Act 1995, because of its unmanned character (British Maritime Law Association, 2018). Croatia stated that a ship is considered seaworthy only if it meets

the minimal qualified crew requirement according to Croatian Maritime Code (Croatian Maritime Law Association, 2018). Thus, the mandatory requirement of the crew in domestic law may be the key to whether an unmanned ship can be regarded as a “ship”. Like international conventions, an unmanned non-military ship may constitute a “ship” for which the above laws and regulations apply if all definitions of the ship in a country’s domestic law do not include the element of the on-board crew.

### 3.2 Does the unmanned ship need seaworthiness?

Seaworthiness refers to the ability of the ship to navigate at sea, that is, whether the ship could cope with risks. Article 3 of the International Convention for the Unification of Certain Rules of Law relating to Bill of Lading (Hague Rules), the Protocol to Amend the International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading (Hague-Visby Rules) provides the seaworthiness of the ship, including the carrier should be “bound before and at the beginning of the voyage to exercise due diligence to properly man, equip and supply the ship.” (1(b)). For an unmanned ship, it does not meet the obligation of “properly man”, does that mean unmanned ships are not seaworthy?

According to the provision, the principle is divided into three aspects: physical fitness; cargo worthiness, and crew competence (So and Poomintr, 2021). The carrier shall ensure the seaworthiness of the ship so that the cargo could be delivered to the destination safely and smoothly. Based on this understanding, seaworthiness does not focus on the number of the crew, but on ensuring that the crew has the professional competencies to ensure the seaworthiness of the ship. What about the number of crew members required by existing international conventions? The Convention on the Safety of Life at Sea (SOLAS) Regulation V/14 requires that “all ships be sufficiently and efficiently manned”. Similar provisions also appear in the UNCLOS, the flag states shall ensure safety at sea with regard to “the manning of ships”. (Article 94)

Let’s take the Principles of Minimum Safe Manning (resolution A. 1047(27)) adopted by the IMO in 2011 as an example to consider this further. The objective of this principle is to ensure that the ships are adequately, effectively, and efficiently manned to ensure their safety (IMO, 2011). By determining the minimum number of crew members for a ship, the core purpose of this principle is “safety”. However, with the development of technology, the principle seems to have no effect on unmanned ships when they could safely operate autonomously. What are the safety standards for unmanned ships at this time?

In fact, the principle considers that the minimum safe manning of a ship should be established considering all relevant factors, including “level of ship automation” (Annex 2, Article 1.1.3), this seems to provide a basis for the safety rules of unmanned ships. Compared with the minimum number of crew members on board, the equipment and technical safety standards on board should be regarded as the safety judgment rules of unmanned ships. Similarly, the SOLAS and UNCLOS are both aimed at maritime security. As Veal and Ringbom’s explain, the purpose of the conventions is to

establish a method to enable the relevant management authorities to meet the safety certificate for ship staffing, rather than requiring any particular mode of operability (Ringbom and Veal, 2017).

Therefore, for the unmanned ship, even if there is no on-board crew, the seaworthiness should not be violated. If the unmanned ship has on-shore remote-controllers, they should have the corresponding ability to remotely control the ship for seaworthiness of the ship. This should be the immediate response that we should consider, while when the technology is developed to the extent that the ship’s operating system could make decisions and determine actions on its own, traditional principles of seaworthiness will no longer be applicable, as human can pre-programming, but could not control decisions anymore (So and Poomintr, 2021).

### 3.3 Does the unmanned ship still need master and crew principles?

Since unmanned ships no longer require a master or crew, legal principles such as the Maritime Labour Convention (MLC), the International Convention for the Safety of Life at Sea (SOLAS), and the International Convention on Standards of Training, Certification and Watch-Keeping for Seafarers (STCW) seem to be inevitably losing relevance. However, considering that unmanned ship needs to be remotely controlled or pre-programmed, can these remote-controllers or programmers be considered captains or crew members? Should they be restricted by relevant laws?

The IWG questionnaire addressed questions about the status of remote-controllers (CMI, 2018a).

*Sub-question 1: Could the chief on-shore remote-controller constitute unmanned ship’s master?*

*Sub-question 2: Could other remote-controllers constitute the “crew” for the purposes of your national merchant shipping laws?*

13 countries replied that their domestic laws defined the term “master”, and 4 countries specify that the “captain” should be on board, including China. Some countries believe that the remote-controller of the unmanned ship could be identified as the master, as their domestic laws do not stipulate that the master must be on board, so whoever control and command the unmanned ship could be regarded as the master. The variety in the answers to this question seems to be due to the traditional understanding of the possibility of the master accommodating a remote controller, or the abilities of the remote controller to fulfill the master’s obligations. It is obvious that a remote controller cannot be considered a master if considerations are made based on his ability to perform his duties as captain. For this reason, countries that clearly define a “master” in their domestic laws are more inclined to conclude that if the remote controller is responsible for controlling the ship, then he could be considered a captain (CMI, 2018a).

Let’s take China’s Maritime Code as an example for analysis. Article 31 of the law defines the “crew” as an entire complement “on board”, including the master. Article 35 states that the master shall be responsible for the “management and navigation” of the ship. The law identifies the master as nothing more than the man who

commands the ship during the voyage, and when the ship is in danger, the master should make decisions about the situation<sup>2</sup>. Hence, our opinion is that the unmanned ship with remote control from shore, the on-shore remote-controller who remotely manages and controls the ship should be considered as “master” regardless of whether they are on board, this is also recognized by MUNIN’s study that on-shore remote controller will serve as the master for the navigate and monitor the ship (MUNIN, 2013), while the programmer of the pre-programming unmanned ship should not be considered as “master” for the lack of participation in the operation of the ship on the sea.

In the above analysis of the seaworthiness of unmanned ships, it has been made clear that the number of crew members does not affect the seaworthiness. The next question to be raised here is whether the duties of the master or crew will be changed, or whether any conventions that govern the master or crew will be invalidated. The crew must receive adequate training and ensure good management of the ship while at sea. According, the International Convention on Standards of Training, Certification and Watch-Keeping for Seafarers (STCW) provides the professional competencies of the crew. There are lots of clauses regarding the duty of watchkeeping and lookout, both require the use of sight and hearing, and it seems clear that only humans could achieve that. Unmanned ships that rely on camera sensors, radar and control algorithms cannot replace the human input needed to assess situations and collision risks (Ringbom and Veal, 2017). The AAWA report also proves that the incorporation of good seamanship into any autonomous navigation scheme will face serious difficulties (AAWA, 2016).

The analysis suggests that human assessment, leadership and intuition cannot be replaced by technology for the time being under the current legal framework. Therefore, the STCW convention, which is based on his standard and has crew employment as its main provision, should not be applied to unmanned ships.

### 3.4 What are the collision and rescue of the unmanned ship?

More than 80% of accidents at sea are caused by human errors (Portela, 2005). Unmanned ships may reduce collisions caused by human errors (as the ships no longer have masters and crews), but accidents shall inevitably continue to occur. The COLREG was formulated by the IMO, it requires the on-board crew to take positive measures during navigation, berthing and operational activities to prevent collisions, stranding and other accidents. How can an unmanned ship meet the convention’s requirements without a crew?

Article 5 of the COLREG specifies the obligation of the ship to “Look-out”, that is:

*At all times maintain in a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing situation and of the risk of collision.*

Obviously, this provision is made on the premise that ships are manned, but this does not mean that unmanned ships cannot and should not comply with the provision. This obligation can be fulfilled by designing and improving the look-out systems of unmanned ships, advanced equipment such as sensors can sense specific dangers encountered by ships at sea, if the remote controllers have received the necessary training to master professional navigation skills, it does not violate the original intention of the COLREGS for providing good seamanship, which is to avoid collisions and ensure safety at sea (Chang et al., 2020).

Another important convention is the 1910 International Convention for the Unification of Certain Rules of Law with Respect to Collision Between Vessels, liability for fault in the collision should be governed by this convention (Articles 3, 4). The presence of the unmanned ship should not change the application of the convention, as the ship itself, not the master or crew, is the subject of the collision. This is also reflected in Article 8 of the convention, which sets out the duty of the master to assist in the event of a collision (the only clause in the convention dealing with the master’s liability). In other words, if the collision of the unmanned ship is caused by remote-controllers or programmers, there should be no change in the current liability system under the convention, the shipowners shall be held responsible for actions caused by the negligence of the remote-controllers or programmers of the unmanned ship.

Hence, while the advent of the unmanned ship may change several of the convention’s clauses, such as “the damage caused to any things or persons on board” (Article 1), collision law seems to be able to stand up well against the arrival of unmanned ships (Van, 2014).

For the salvage of the unmanned ship, the same situation may also occur as the collision, that is, there will be a reduction in salvage operations of human factors. Similarly, if technology permits, the unmanned ship will be able to carry out salvage operations on other unmanned or manned ships, salvage regulations will also continue to play a role (Van, 2014).

Furthermore, based on the characteristics of the unmanned ship, several contents of the salvage conventions should be adjusted. Article 11 of the Convention for the Unification of Certain Rules of Law Related to Assistance and Salvage at sea specifies that the master is bound “to render assistance to everybody, found at sea in danger of being lost”, the UNCLOS stipulates that the captain has the duty to “render assistance to any person found at sea in danger of being lost” (Article 98). The above provisions on the salvage duty of the master will no longer apply to the unmanned ship without a master or crew on board. Instead, the salvage responsibility of remote-controllers or programmers should be clarified.

## 4 China’s attitude and challenges

### 4.1 Laws and regulations in China

China’s unmanned ship technology is in the stage of rapid development. At the same time, how to improve the legal regulation

<sup>2</sup> Article 36 to Article 40 of the Maritime Code stipulated the specific measures that can be taken by the master.

of unmanned ships and how to integrate domestic law with international law are also issues that need to be considered. As a member of IMO, China is also a state party to the UNCLOS, SOLAS, STCW and other international conventions, and should be regulated by these treaties.

We can make it clear that unmanned ship is subject to and regulated by Chinese laws. Shipping laws and regulations in China are relatively complete (as shown in Table 1<sup>3</sup>) and there are many discretionary provisions in the current laws and regulations, which also reserve a certain space for the legal interpretation and legal application of unmanned ships. The first is whether an unmanned ship can be defined as a “ship”. The Maritime Code of the People’s Republic of China mainly regulates the civil legal relations relating to maritime transport and ships. Article 3 defines the ship as “sea-going ships and other mobile units, but does not include ships or craft to be used for military or public service purposes, nor small ships of less than 20 tons gross tonnage.” Another important law in China is the Maritime Traffic law of the People’s Republic of China revised in 2021, which defines “ship” as “various types of draining or non-draining vessels, boats, rafts, water crafts, submersibles, mobile platforms and other mobile devices.” All definitions of the “ship” in China’s existing laws and regulations do not include the element of the on-board crew, which is consistent with the legal conclusion that an unmanned vessel can constitute a “ship” as analyzed above.

China has always attached great importance to shipping safety. Relevant provisions on ship safety are reflected not only in the international conventions to which China has acceded (such as SOLAS), but also in its domestic laws. SOLAS’s safety manning rules require ships to have sufficient and qualified crews to ensure the navigation safety, but leave the minimum standard of “sufficient number” to the flag State to determine, while China’s domestic laws have clear provisions on the qualification of crew members and the safe manning of ships. For example, the Maritime Traffic Law of China clearly stipulates that the ship shall satisfy the requirements for minimum safe manning and appoint crew members who hold valid certificates of qualification. Similar provisions also appear in the Minimum Safety Manning Rules for Ships of China and the Regulation on Seamen of China. From the perspective of purpose interpretation, the safety manning rules are designed to ensure the safe and reliable execution of ship navigation tasks, and these rules may no longer necessary if unmanned ships rely on their intelligent technology to complete navigational tasks (Chen, 2023).

China has begun to formulate and publish regulations on the management of unmanned ships as shown in Table 2. China’s Ministry of Industry and Information Technology, Ministry of Transport and other authorities jointly formulated the Action Plan for the Development of Unmanned Ships (2019-2021), which, in addition to breakthroughs in key intelligent technologies, also plans to build and revise a system of specifications and standards for unmanned ships (GOV, 2018). In

TABLE 1 Main shipping laws and regulations in China.

Maritime Laws and Regulations	
Maritime Code of the Peoples’s Republic of China	
Maritime Traffic law of the People’s Republic of China	
Maritime Environment Protection Law of the People’s Republic of China	
Law of the People’s Republic of China on Ports	
Waterway Law of the People’s Republic of China	
Special Maritime Procedure Law of the People’s Republic of China	
Administrative Laws and Regulations	
Navigation Safety	Ship Supervision
Regulation of the People’s Republic of China on the Administration of Navigable Waterways	Regulations of the People’s Republic of China Governing the Registration of Ships
Regulation Governing Supervision and Control of Foreign Vessels by the People’s Republic of China	Regulations of the People’s Republic of China on the Investigation and Handling of Maritime Traffic Accidents
Pollution Prevention	Industry Management
Regulation on the Prevention and Control of Vessel-induced Pollution to the Marine Environment	Regulation on the Administration of Domestic Water Transport
Regulations of the People’s Republic of China on the Dumping of Wastes at Sea	Regulations of the People’s Republic of China on International Ocean Shipping
	Regulation of the People’s Republic of China on Seamen
Departmental Regulation	
Management on Ship and Crew	Ship Supervision
Rules of the People’s Republic of China on the Safety Supervision of Ships	Detailed Rules for the Implementation of the Regulations of the People’s Republic of China on International Maritime Transportation
Measures of the People’s Republic of China for the Registration of Vessels	Provisions on the Administration of Port Operations
International Vessel Security Rules of the People’s Republic of China	Regulations of the People’s Republic of China on Ship Survey
Rules of the People’s Republic of China for the Minimum Safe manning of ships	Administrative Provisions of the People’s Republic of China on the Prevention and Control of Marine Environmental Pollution by Vessels and Their Operations
Regulations on Watchkeeping for Seafarers on Seagoing Ships of the People’s Republic of China	Provisions on the Safety Supervision and Administration of Carriage of Hazardous Goods by Vessels
Rules of the People’s Republic of China for the Competency Examination and Certification of Seafarers Serving in Seagoing Ships	Provisions of the People’s Republic of China on the Administration of Emergency Preparedness for and Emergency Response to Vessel-Induced Pollution to the Marine Environment

<sup>3</sup> Due to the limitation of space, only important laws and regulations, or those related to the research of this paper are listed in the table.

TABLE 2 Guidelines and norms of unmanned ships formulated in China in recent years.

Name of Guidelines and Norms	Issuing Authority	Time in Force
Rules for Intelligent Ships (2015)	China Classification Society (CCS)	2016
Inspection Guides of Unmanned Surface Vehicle (USV) (2018)	China Classification Society (CCS)	2018
Guidelines for Autonomous Cargo Ships	China Classification Society (CCS)	2018
Action Plan for the Development of Unmanned Ships (2019-2021)	Ministry of Industry and Information Technology, Ministry of Transport and other authorities jointly formulated	2018
Action Plan for Promote the Intelligent Transformation of Ship Assembly and Construction (2019-2021)	Ministry of Industry and Information Technology, Ministry of Transport and other authorities jointly formulated	2018
Guidance on the Development of Intelligent Shipping	Ministry of Industry and other seven authorities jointly formulated	2019
Construction Guide of Intelligent Ship Standard System	Ministry of Industry and Information Technology	2020
Rules for Intelligent Ships (2020)	China Classification Society (CCS)	2020
Implementation Opinions on Accelerating the Green and Intelligent Development of Inland waterway Vessels	Ministry of Industry and Information Technology, and other five authorities jointly formulated	2022
Rules for Intelligent Ships (2023)	China Classification Society (CCS)	2023
Inspection Guide of Intelligent Ship Engine Room	China Classification Society (CCS)	2023
Inspection Guides of Unmanned Surface Vehicle (USV) (2024)	China Classification Society (CCS)	2024
Rules for Intelligent Ships (2024)	China Classification Society (CCS)	2024

the Rules for Intelligent Ships compiled by the China Classification Society (CCS), the requirements of hull structure, navigation, cargo management and intelligent system are clarified according to the particularity of unmanned ships, and the technical requirements could also be used as a reference for future domestic legislation. In general, China's policies provide guidelines and norms to encourage the development of unmanned ships, but it is also important and urgent to provide legal guarantees for them, which is widely recognized in China (Han and Xia, 2021).

## 4.2 Controversies and trends

It should be noted that the Ministry of Transport of China (MOT, 2018) organized a revision of the Maritime Code in 2018. In

the revised consultation paper released in November 2018, there are no specific provisions for unmanned ships. But in other provisions, the person who must hold the appropriate certificates of competency is amended from the "master, deck officers, chief engineer, engineers, electrical engineer and radio operator" (Article 32) to "crew members who take part in the navigation and engine duty" (Article 3.2). This change does not specifically distinguish between the duties and types, leaving the leeway for the on-shore remote controllers of unmanned ships to be interpreted as crew members and for the applications of the Maritime Code to unmanned ships. After the revised consultation paper was released, there were lots of discussions among Chinese scholars about whether to add clauses specifically dealing with unmanned ships to the new law. At the Ninth International Conference on Maritime Law held in Shanghai, scholars proposed that we should design an appropriate legal framework for the new business model of unmanned ships, analyze and supervise possible information technology problems during navigation (SMU, 2018). As Qu pointed out, the advent of the era of unmanned ships will not lead to the disappearance of maritime law, on the contrary, maritime law should regulate and promote the development of the unmanned ship transport industry (Qu and Shen, 2021). (At the time of writing this paper, the revised Maritime Code has not been promulgated.)<sup>4</sup>

It is obvious that the development of unmanned ship technology will pose a challenge to the above-mentioned Chinese ship legislation. The existing laws in China do not explicitly state that the regulatory objects include unmanned ships without on-board crews, so unmanned ships could only be incorporated into the regulatory scope of China's ship regulations through legal interpretation. The requirements for crew and ship technology in the existing ship legislation are not applicable to unmanned ships. For example, Article 7 of the Regulations of Governing the Registration of Ships provides that "Seafarers on board ships of Chinese nationality who are required to possess certificates of competency shall hold the appropriate certificates of competency issued by China." This provision is contrary to the characteristics of unmanned ships. Meanwhile, unmanned ships are currently unable to obtain Chinese ship registration and pass Chinese ship inspection, as they do not meet the provisions of the current Regulations of Governing the Registration of Ships and the Regulations of Governing Survey of Ship and Off Shore Installations, which will also pose a big obstacle to the development of commercial unmanned ships in China (Xu and Xuan, 2019).

The rise of unmanned ship technology is impacting domestic ship legislation, but at least in China, the Maritime Code, the Maritime Traffic Safety Law, the Regulations of Governing the

<sup>4</sup> The revised consultation paper can be found on the official website of the Ministry of Transport of the People's Republic of China, available at [https://xxgk.mot.gov.cn/jigou/fgs/201811/t20181105\\_3109896.html](https://xxgk.mot.gov.cn/jigou/fgs/201811/t20181105_3109896.html). At the time of writing this paper, the revised Maritime Law has not been promulgated. The Ministry of Transport has made it clear in its 2022 Legislative Plan that the revised law will be issued this year.



Registrations of Ships, and other laws have not included the unmanned ship in the scope of legal regulation, it will be extremely slow and lagging if we continue to wait for the revision of international conventions before the domestic transformation and application (Li et al., 2020). In this case, China's domestic legal regulation becomes important.

On the one hand, the legal status of unmanned ships in China's legal system needs to be clarified. In fact, many countries have already paid attention to the legislation of unmanned ships. For example, South Korea's newly formulated Autonomous Navigation Ship Law will be implemented in January 2025, which makes special provisions for unmanned ship inspection, unmanned ship facility standards, crew staffing, and other related issues (MOF, 2023). In our view, domestic law should clarify the basic concepts and legal status of "unmanned ship", "crew member" and "on-shore remote-controller", in particular how the legal status of "on-shore remote controller" can be reconciled with the existing legislative provisions ("crew members" must be "person on board.") An exemption clause should be added to the existing Minimum Safety Manning Rules. As long as unmanned ships can meet the safety standards stipulated by domestic laws and regulations, they do not need to be restricted by "minimum safety manning". The obligations of crew members in the current law cannot be directly applied to on-shore remote controllers, and the same part of the on-shore remote-controllers and traditional crew members (such as management and driving duties) should be retained and applied, while the different parts of qualification, training, etc., should be separately provided for. On the other hand, in the newly revised Maritime Code, it is necessary to stipulate the liability of the unmanned ship carrier, the principle of liability for ship collision, maritime salvage, and other aspects. The single-fault liability principle is difficult to completely regulate the unmanned ship, so the no-fault liability principle should be considered to solve the collision problem caused by the unmanned ship. At the same time, clear provisions should be made on how to divide liability. Based on the purpose of coping with the risk at sea, the unmanned ship, as a kind of "ship", should perform the duty of rescue within the scope of technology. As the party salvaged, the relevant provisions on property salvage and prevention of marine environmental pollution may be applied.

In general, unmanned ships are generally applicable to the ship-related legal system under the current Chinese laws and regulations, but it is difficult to apply some specific legal rules to unmanned ships. For maritime management rules, existing regulations should be modified to conform to the characteristics of unmanned ships, such as modifying the relevant provisions of "minimum safety manning", while specific technical rules for unmanned ships should be formulated. As for maritime law rules, it is necessary to keep up with the legislative trends of the international community and improve the liability of the carrier of unmanned ship transport, the principle of liability for ship collision, maritime salvage, and other issues. In this process, China should actively and deeply participate in the development of unmanned ship regulatory framework projects of international organizations such as IMO, so that the revised domestic law can be consistent with international conventions as far as possible, and avoid the occurrence of conflicts between domestic law and international conventions. China has

formulated good policies, guidelines, and norms to encourage the development of unmanned ships, and the legal system should also be actively improved to provide legal protection for the development of unmanned ships while leaving certain room for fault tolerance and innovation (Han and Xia, 2021).

## 5 Conclusions

Through analysis, we found that there seem to be unknown risks that are not reflected and restrained in the current international conventions. Traditional rules of navigation have largely been developed to meet the needs of manned transportation, the human element is evident in every corner of the current regulatory framework (Rodriguez-Delgado, 2018). For this reason, even if unmanned ship technology is widely used, it may be difficult to change the principles of the existing international conventions. This was also confirmed by the MUNIN's results (MUNIN, 2012). Therefore, we must consider and overcome these legal barriers before the unmanned ship could be fully commercialized. In this regard, the solution to the legal regulation of unmanned ships is to amend every convention, which is probably the most significant. But this would only exist in an ideal world, where reviewing and revising each convention line by line, to be agreed upon by a host of countries, is a difficult and almost impossible task (CMI, 2018b).

Conventions including SOLAS, COLREG, STCW, etc. were listed as the "High-priority instruments" of the MASS regulatory assessment conducted by the MSC in May 2021 (IMO, 2021). In a study carried out by the IWG, it selected 8 conventions that are most relevant to unmanned ships and most in urgent need for review, including the SOLAS, STCW, COLREGS, etc (CMI, 2015). This seems to indicate that international organizations have identified conventions that may need to be revised. But obviously, it is not possible to transfer existing liability rules that apply to traditional manned maritime activities to unmanned maritime activities (Ringbom and Veal, 2017). Amending existing conventions or enacting new laws could not take effect immediately, as they affected many countries, industries, and other matters (Cheng and Ouyang, 2020).

Is the current strategy of reviewing the convention effective for the IMO? Perhaps we should look at it in conjunction with the development of unmanned ship technology. Remotely controlled unmanned ships are the first to be enter into operation, but are not covered by the current international convention framework. The ability of available technologies to ensure safety at sea to the same degree or better than that of manned ships is the objective of all current conventions. Until truly unmanned ship technology completely replaces manned ships, IMO's strategy will continue to provide a useful regulatory framework for shipping. Also, it should be noted that the current scoping exercise carried out by IMO is too slow, with drafting, negotiation, and adoption phases that could take years to complete and are unable to keep pace with the rapid development of autonomous technology (Katsivela, 2018). Within the framework of existing international conventions, the inclusion of unmanned ships by amending a large number of

existing instruments seems to be a more suitable long-term solution, either through the introduction of a dedicated unmanned ship convention or the design of detailed unmanned ship regulations in the SOLAS or other conventions (Osaloni and Ayeni, 2022; Stępień, 2023).

Based on the above analysis, we believe that IMO could continue to carry out more work for the unmanned ship. For example, to interpret or revise existing IMO instruments to make them equally applicable to unmanned ships. As it seems easier than amending these international conventions to clarify the meaning of generic terms, such as the ambiguity of the concept of “ship” which has led to confusion over the legal status of the unmanned ship. If the legal status of the unmanned ship is clarified through the IMO definition of “ship”, a series of extended legal problems will be solved. Meanwhile, IMO could establish codes of conduct, standards, or guidelines for the unmanned ship, provide a platform or forum for countries to discuss issues related to the unmanned ship, and promote international cooperation in the field of unmanned ship shipping. Additionally, we could be quite sure that when the era of fully autonomous unmanned ships arrives, an important project would be needed in the future: a specifically international principle for unmanned ships. But a new mandatory rule would be a long way off, perhaps taking decades or even centuries.

From a national perspective, what changes could be made to domestic law to prepare for the coming era of unmanned ships? There is no doubt that the coordination between a country’s maritime legal system and the unmanned ship will affect the future development of unmanned ship transportation. Responses in the IWG questionnaire reflect differences in the degree of coordination among countries (Qu and Shen, 2021). In the context of new technology, the management, operation, and maintenance of unmanned ships by shipowners and carriers are not the same as that of ordinary ships, so domestic laws must be changed to the existing rules. Specifically, the legal positioning of the unmanned ship should be clarified, which is the basis for effective regulation of the unmanned ship. On this basis, the existing maritime management rules should be revised, and specific technical rules for unmanned ships should be formulated to make them conform to the development characteristics of unmanned ships. Considering the collision of unmanned ships, maritime salvage and other issues should also be improved by Maritime Code. Of course, during this process, the countries also need to cooperate with the IMO to ensure that unmanned ships

fully comply with the requirements within international rules and standards.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

## Author contributions

YS: Conceptualization, Data curation, Methodology, Project administration, Writing – review & editing. YY: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. YM: Project administration, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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