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A legal study on challenges confronted by unmanned ships

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A LEGAL STUDY ON THE CHALLENGES CONFRONTED BY UNMANNED SHIPS

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation: **A legal study on challenges confronted by unmanned ships**

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The epidemic of autonomous technology expand and spread to shipping industry with a fast speed. Unmanned ships is developed under such background. Existing international conventions are established with a basis of conventional ships. The development of unmanned ships has brought great challenges to the existing maritime legal system. This dissertation is a study of legal challenges confronted by unmanned ships.

Based on the questionnaire handed out by the International Working Group on Maritime Law on Unmanned Craft, its position paper and Responses from various countries, the dissertation proposes suggestions to overcome the difficulties related to the application of international conventions and regulations that unmanned ships are faced with.

The dissertation is divided into five chapters. Chapter I gives a introduction of the background of unmanned ships, reviews the previous research and explains the objective and significance of this study. Chapter II analyzes the legal status of unmanned ships. Chapter III explores the difficulties confronted by unmanned ships related to application of international conventions and regulations. Chapter IV renders suggestions to deal with these legal challenges. Chapter V comes to a conclusion of the disstertation.

KEY WORDS: unmanned ship, legal status, remote controller, autonomous system

LIST OF ABBREVIATIONS

CCS	China Classification Society
CLC	International Convention on Civil Liability for Oil Pollution Damage
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
EEZ	Exclusive Economic Zone
EDA	European Defence Agency
EU	European Union
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IACS	International Association of Classification Soceities
IAIN	International Association of Institutes of Navigation
IMarEST	Institute of Marine Engineering, Science and Technology
IMO	International Maritime Organization
IWGUS	International Working Group Unmanned Ships
MARPOL	International Convention for the Prevention of Pollution from ships
MASS	Maritime Autonomous Surface Ships
MCA	Maritime and Coastguard Agency
MSN	Merchant Shipping Notice
MUNIN	Maritime Unmanned Navigation through Intelligence in

	Networks
SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
UAV	Unmanned Aircraft System
UNCLOS	United Nations Convention on the Law of the Sea

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CHAPTER 1

INTRODUCTION

1.1 Background Information

With the rapid development of communication and information technology and the rapid development of artificial intelligence technology, the degree of automation is getting higher and higher for ships. In the aspects of military, hydrographic surveys, marine scientific research and maritime administration, ships that are driven by remote control center without crew on board have already been in use and put into service. Great improvement of autonomous technology brings opportunities for the commercialization of unmanned ship, especially in the United Kingdom, the United States, the European Union(EU) and other countries.

In May 2012, PAPAMAU, a wave glider made by California- and Hawaii-based tech firm Liquid Robotics, set out from San Francisco to sail across the Pacific ocean to Astralia for approximately 9,000 nautical miles (16,668 kilometers). The journey demonstrates the possibility for long-distance travel by an autonomous ship.1 The European Defence Agency(EDA) under the European Commission is conducting research on safety, regulation and legislation in the design and operation of unmanned ships. In addition, the EU invested 3.5 million euros to the sea unmanned intelligent navigation network project. The program of Maritime Unmanned Navigation through Intelligence in Networks(MUNIN）is dominated by Norway, studying the feasibility of the implementation of autonomous technology at sea through intelligent networks and the construction of test-bed. The program aims at developing unmanned ships that

[1] Paul W. Pritchett, Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology, (2015) 40 Tulane Maritime Law Journal 197, from Ben Coxworth, First of Four Autonomous Wave Glider Robots Successfully Crosses Pacific Ocean, http://newatlas.com/wave-glider-arrives-australia/25316/.

are remotly controlled and fully autonomously controlled. Moreover, the program covers the legal issues of unmanned ships as well。In the United Kingdom， Rolls-Royce has an unmanned ship program in 2017 dedicated to the development of commercial unmanned vessels, together with Svizer. A large amount of investment was put into the development of the technology of bulk carrier and announcement was issued that it is expected to engage in unmanned passenger ships on the Nordic coast by 2020. Rolls-Royce also reached an agreement with Google to build an intelligent awareness systems for unmanned ships. Special Committee was established by the British Ministry of Commerce to draft a legal framework for unmanned ship, trying to solve the problem of the application of unmanned ships under the IMO legal system. In addition, the International Association of Institutes of Navigation(IAIN) and the Institute of Marine Engineering, Science and Technology(IMarEST）submitted a report on the problems of application of law of unmanned ships at the 95th International Maritime Organization Maritime Safety Committee meeting in April 2015, together with the British Ministry of Commerce.

In China, Harbin Engineering University and Shenzhen HiSiBi Company developed the fastest unmanned surface vehicle in December 2017. On February 10, 2018, the offshore test site of the Wanshan Unmanned ship in Zhuhai, Guangdong Province began construction, which was totally 225 square nautical miles. The China Classification Society(CCS), the team form te Intelligent Transportation System Research Center of Wuhan Institute of Technology, Yunzhou Intelligent Company in Zhuhai and Zhuhai Municipal Government jointly cooperate to promote the independent development of Chinese unmanned ships.

The research on the marine autonomous systems and the study on legal issues of

unmanned ships are not only popular in many countries, but also attracted the attention of international organizations. In February 2017, nine countries including Denmark jointly proposed to the International Maritime Organization that the regulation of Maritime Autonomous Surface Ships(MASS) be included in the scope of their work. The proposal was formally adopted at the 98th International Maritime Organization Maritime Safety Committee meeting in July 2017. It means that the International Maritime Organization(IMO) has officially incorporated the regulation of unmanned ships into its work schedule. International Working Group Unmanned Ships(IWGUS) was established by Committee Maritime International（CMI) with an aim at identifying and resolving conflicts between unmanned ships and the current maritime legal system. The working group released questionnaires to members in March 2017. By June 2019, 23 countries including China, the United States, and the United Kingdom had replied.

In fact, some national authorities have allowed certain small unmanned vessels to operate in controlled sea areas between these countries with the issuance of notice. Studies have shown that unmanned ships have certain advantages over conventional ships in terms of reducing costs, overcoming the hard working environment at sea, reducing the risk of human factors and marine environmental protection. Therefore, autonomous technology has received more and more attention. The reality seems to convince people that autonomously controlled ships will likely replace the current manned ships to sail between ports around the world.

1.2 Review of Previous Research

Prof. Dr. Eric Van Hooydonk, University of Ghent, Belgium, published “The Law of unmanned merchant shipping- an exploration”. From the angle of the definition of

ship, the jurisdiction of the flag state, the identification and responsibility of the captain's crew, the paper analyzes the legal issues involved in the operation of unmanned ships. The paper lays the framework foundation for the questionnaire of the unmanned ship working group. Robert Veal and Prof. Dr. Michael Tsimplis, University of Southampton, jointly published the integration of unmanned ships into the lex maritima in May 2017. From the angles of both international public law and private international law, the unmanned ship can be regulated by the current maritime legal system. Paul W. Pritchett and Michael Chwedczuck have studied the legal status of commercial unmanned cargo ships under US maritime law from the perspective of domestic law. In addition to the above, the analysis of the ship's airworthiness, pirates, and cargo damage are carried out from a practical perspective. CAI Yuliang and MA Jilin pointed out that unmanned ships should have the characteristics of perception ability, memory and thinking ability, learning and adaptive ability and behavioral decision-making ability, and believed that the changes brought by intelligent ships would make the existing maritime convention framework unable to meet the requirements2. Through the analysis of the trend and pattern of unmanned ship, SHI Wentao explores the contradiction between current international rules and demand of unmanned ships. The paper argues that the establishment of international rules for unmanned ships should be based on the international conferences and achieved by making plans, setting up joint working groups, seeking international cooperation, etc3. Wang Xin and Chu Beiping, Dalian Maritime University, have published the paper "Legal barriers confronted by unmanned ships under trialing and reaction"4. In this

[2] Cai Yuliang, Ma Jilin. (2017). The influence of the development of unmanned ships on the International Maritime Conventions, *China Ship Survey,* p10—15.

[3] Shi Wentao. (2017). Discussion on the effect of unmanned vessel to international rules and associated countermeasures, *China Maritime Safety,* p32—35.

[4] Wang Xin, Chu Beiping. (2017). Legal barriers confronted by unmanned ship under trialing and reaction. *Chinese Journal of Maritime Law,* p59-67.

paper, comprehensive analysis has been madde on legal issues such as legal status of unmanned ships at the trialing stage, the assumption of civil liabilities for marine accidents involving unmanned ships and the insurance on those ships.

1.3 Object of Study

The dissertation mainly studies the legal issues of unmanned ships with the beginning of the legal status of the unmanned ship. Taking maritime international conventions as the object of study, this dissertation discusses which rules can still be applied to unmanned ships, which rules need to be amended and which new rules need to be formulated. At last, the author proposes pieces of suggestions related to application of the international conventions and regulations, including SOLAS, COLREGS and STCW.

1.4 Significance of Study

The development of commercial unmanned vessels at sea is inseparable from the technical, economic and commercial promotion. Moreover, it is closely related to the policy and legal support. The international nature of shipping determines that the regulation of unmanned ships should not only rely on domestic laws and regulations, but also need unified and coordinated international rules. Immature technology and vague rules are the deadliest killer of new things. Since the technical research and development of unmanned ships in all aspects must go through numorous tests and continous improvements before they are allowed to be officially operated in commercial maritime transport. Relevant laws and regulations should be prepared for

the possible problems arising from the development of unmanned ships.The study on the legal challenges faced by unmanned ships and the corresponding solutions can not only avoid impeding the technological progress of unmanned ships, but also lead the development of technology to some extent.

CHAPTER 2

Uncertainty in the legal status of Unmanned ships

2.1 Definition of Unmanned Ships

According to the questionnaire and position paper of the International Working Group, unmanned ships have four elements:

a.No on-board crew;

b.Movable;

c.The movement is controlled;

d. The moving range is on the sea water.

Basic characteristics of conventional ships for commercial purposes are as follows:

a.Reactivity;

b.The movement is controlled on the surface of the water;

c.It has the ability to carry people or cargo;

d.It is engaged in navigation at sea.[5]

We can see that the most significant difference between unmanned ships and conventional ships is whether they carry crew or not. So, could the unmanned ship constitute a "ship"? Detailed analysis will be made below.

2.1.1 Definition under international conventions

In international law, the existing sources of law related to ship and Marine safety and environmental protection mainly include the 1982 UNCLOS convention and international conventions such as SOLAS, COLREG and STCW. UNCLOS stipulates the obligations of flag state and the right of navigation, but does not give a clear

[5] Wang Xin, Chu Beiping. (2017). Legal barriers confronted by unmanned ship under trialing and reaction. *Chinese Journal of Maritime Law*, p61.

definition of ships. Due to the different aims and focus of international conventions, there is no uniform definition of ship. Article 1 of the 1924 international convention on the uniform law of bills of lading provides that ships are used for the carriage of goods. The 1989 United Nations convention on conditions for registration of ships stipulates that "any sea-going vessel of its own type, whether used for the carriage of goods, passengers, or both, in international maritime commerce, with the exception of vessels of a gross tonnage of less than 500 tons". According to Rule 3 of COLRES, the word”vessel” includes every description of watercraft, including non-displacement craft and seaplanes, used or capable of being used as a means of transportation on water. According to Art. 2 of MARPOL, “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. According to Art.1 of SUA, “ship” means a vessel of any typewhatsoever not permanently attached to the sea-bed, including dynamically supported craft, submersibles, or any other floating craft. The International Convention on the clearance of wrecks also adopts similar definitions of ships also adopts similar definitions of ships which means a seagoing vessel of any type whatsoever and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft and floating platforms, except when such platforms are on location engaged in the exploration, exploitation or production of seabed mineral resources. Summing up the above definitions of ship under international law, several elements of defining a ship can be extracted: (1) self-navigation; (2) it can be used to transport people or goods; and (3) it is operated at sea. In a particular field, for a particular purpose, the definition of a ship does not emphasize the navigational capacity of the ship and expands the scope of the ship as much as possible, such as the field of environmental pollution. For instance,

according to Art.1 of CLC, ship means any sea-going vessel and seaborne craft of any whatsoever constructed or adapted for the carriage of oil in bulk as cargo, provided that ship capable of carrying oil and other cargoes shall be regarded as a ship only when it is actually carrying oil in bulk as cargo and during any voyage following such carriage unless it is provided that it has no residues of such carriage of oil in bulk abroad. The scope is very wide that as long as the sea-going vessel or craft is used for the carriage of oil in bulk as cargo, CLC could be aplicable.

At present，there is not a uniform definition of ship for all. Is it necessary to give it a broad definition in UNCLOS to avoid the uncertainty of application of international conventions for unmanned ships? There are some small differences in the definition of different conventions and regulations, however, almost all of them doesn't mention on-board crew. In another word, the crew on board are not the constituent elements of the ship to which the Convention applies, at least in the semantics of the Convention, the unmanned ship is not excluded from its scope of application. The definition of ship has become an internationally accepted habit with different definitions in different fields. UNCLOS leaves each state to grant the right of navigation to whatever craft it determines under its national law to be a ship6, whereas UNCLOS itself, as the Constitution of the Ocean, does not define the ship.

2.1.2 Definition under national laws

According to Art.91 of UNCLOS, the conditions for the registration of ships and the flag of a ship shall be governed by the domestic laws of each country. That is to say that the definition of ships and the determination of their conditions, are the fields of adjustment of domestic law. The definition of ship in different nations is not exactly the same, which even has different meanings in one national legislation. Veal and

[6] Robert Veal，Michael Tsimplis. (2017). The integration of unmanned ships into the lex maritima，*Lloyd's Maritime and Commercial Law Quarterly*, p309

Tsimplis state the possibility to identify a core group of craft that always falls under such a definition in each jurisdiction(Veal&Tsimplis) However, each law or regulation may be enacted with specific views and purpose, thus the extent of application may be different. The flag state is granted exclusive power to decide what a ship is. Therefore, it is flag state's right to determine whether unmanned ship constitute a ship or not.

Q1.1 of the questionnaire of unmanned ship asks whether an unmanned cargo ship of more than 500 gross tons constitutes a ship in domestic law.

When defining ships, many countries do not predict the emergence of unmanned ships, nor do they take into account the fact that ships do not carry crew members.

However, most MLAs state that an unmanned ship would or most likely would constitute a ship under their national law, including China. The laws of individual countries have special provisions for this. For instance，the Panamanian MLA states that although the definition of ship under Panamanian national law is broad enough to include unmanned ships, it is ultimately up to the Administration to decide what a ship is7. Canada has a clear attitude towards this issue. The definitions of ship in both the Canadian Shipping Act and the Federal Courts Act are irrelevant of seafarers. Moreover，in Cyber Sea Technologies, Inc v. Underwater Harvester Remotely Operated Vehicle, canadian court acknowledged that remote-controlled submersibles constitute ships and maintained that the only criterion to judge a ship was that it was at least partially used for navigation, without regard to seafarers. It could be inferred that autonomous ship constitute a ship in Canadian law.

Under Chinese law, the Law of the People's Republic of China on Maritime Traffic Safety, the Law of the People's Republic of China on Marine Environmental

[7] Article 168(13) of Law No.57 of 2008.

Protection, the Regulations on Ship Registration of the People's Republic of China, the Regulations on Seafarers of the People's Republic of China and the Regulations on Ship Inspection and Management are the main sources of law for the adjustment of marine safety and environmental protection related to ships. According to Art.50 of the law of Maritime Traffic Safety, "Vessels" means all types of displacement or non-displacement ships, rafts, seaplanes, submersibles and mobile platforms. The Regulations on Inspection of Ships and Marine Facilities provide similar definitions of ships. According to Art.56 of the Regulations on Ship Registration，Ships refer to all kinds of mobile, non-motorized ships and other water mobile devices, except for lifeboat rafts installed on ships and rafts less than 5 meters in length. Maritime Code of the People's Republic of China mainly regulates the civil legal relations related to maritime transport and ships, in which there are different definitions of ships in different chapters. According to Art.3 in the chapter II, "Ship" as referred to in this Code means 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. The term "ship" as referred to in the preceding paragraph shall also include ship's apparel. According to Art. 165 in the chapter VIII that is Collision of ships, ships referred to in the preceding paragraph shall include those non- military or public service ships or craft that collide with the ships mentioned in Article 3 of this Code. Under Chinese law, only the law of Marine Environmental Protection doesn't provide the definition of ship. Besides, all the definitions of ship in other laws and regulations doesn't include the element of on-board crew. Therefore, the unmanned ship could constitute a ship and apply the above-mentioned laws and regulations.

2.1.3 View on Legal status of unmanned ship

It is ambiguous in logic to identify the legal status of autonomous ship. One of the

reasons is the confusion of whether ship's definition is a concrete or abstract concept[8]. Based on Croatian law, it seems like "ship" is a concrete concept so that autonomous ship cannot constitute a ship because it lacks one of the requirements of "seaworthiness", minimal qualified crew. Under Chinese law, ship is an abstract concept because its definitions are described in a limited scope without referring to constitutive requirements, such as on-board crew. The different definitions of ship under Chinese law are the interpretations of ship for different purposes. All these definitions fall under the concept of "ship". So does the definition of unmanned ships. It is argued that the drafters of the existing laws of various countries did not take into account the possibility of future unmanned ships in drafting the laws, so unmanned ships should not apply these provisions. However, the term "ship" is universal and inclusive enough that the definition of unmanned ship could fall under the scope of it. Unmanned vessels equipped with new intelligent technologies have not changed the fundamental characteristics of ships, so unmanned vessels have the legal status of ships. The unmanned ship equipped with new autonomous technology has not changed the basic characteristics of the ship so the unmanned ship has the legal status of the ship.

In deed, there exist some conflicts for unmanned ships to apply to present conventions, laws or regulations because the provisions are made for conventional ships that are not suitable for unmanned ship. However, it cannot be the reason to explain that unmanned ship cannot constitute a ship no matter under international law or national law. The exclusion of unmanned ship to current legal framework is negative for the development of new technologies. In the future, unmanned ships may be used frequently for more functions, such as commercial operations and scientific research,

[8] Wang Yifei

along with technological advances. They may do the same work, bear the same marine risk and produce safety hazard with conventional ships. What we should do is to figure out how to amend the present provisions so that they can adapt to the development of unmanned ships, instead of excluding them from the current legal framework.

2.2 Level of autonomous and Identification of Crew

Ships are divided into four levels based on degrees of autonomy established by IMO. They are ship with automated processes and decision support, remotely controlled ship with seafarers on board and remotely controlled ship without seafarers on board and fully autonomous ship. The higher the degree of autonomous is, the fewer seafarers the ship has. According to IWG questionnaire and position paper, autonomous ships are divided into two types, remotely controlled and autonomously controlled ship. With regard to the remotely controlled ship, it doesn't mean that no person is needed to operate the ship. Then how to identify the person who remotely controls the ship becomes an important question. Could the chief on-shore remote-controller be considered as master? Could other remote controller constitute crew? With regard to autonomously controlled ship, could the chief pre-programmer and the 'designated' person who is responsible on paper but not immediately involved with the operation of the ship constitute masters?

2.2.1 Remotely controlled ship without seafarers on board.

The remotely controlled ship is operated by on-shore remote controller without seafarers on board. Such ship is fitted with sensors, systems and equipment, such as radio communications, global positioning system. By using these systems, the remote controller could receive information and data to monitor the ship in real time to prevent from the potential hazards, such as flammable atmospheres and electric shock,

etc. However, there may be a slight delay between the equipment and controller. Moreover, it takes time for the controller to react with emergency and make decisions. It is undeniable that human plays a less important role in the remotely controlled ship than conventional ship. However, it doesn't mean that such kind of ship is no need for human. The CMI questionnaire mentions one question with three sub-questions about the identification of crew.

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

Among 23 MLAs, 13 states answered that their domestic laws defined the term "master". Four MLAs answered "Captain" and were clearly on board, including China. According to Art. 31 of Maritime Code of the People's Republic of China, the term crew means the entire complement of the ship, including master. Hence, chief on-shore remote-controller(hereinafter referred to as chief controller does not constitute the master. Under Greek law none of the above persons comply with the notion of Master. Greek law, requires the Master's physical presence on board the vessel under Article 43 of the Code of Private Maritime Law.

11 MLAs answered that their laws did not specify whether the captain should be on board, seven of who (Bri, Can, Fre, Pan, Sin, US, Den) believed that the chief controller could be included in the category of "captain". For example, a master is an individual who actually exercises the command of a ship under French law. As long as the chief controller actually commands the unmanned ship, it can be regarded as the master. Four MLAs (Arg, Can, Dut, Ven) believe that although the definition does not explicitly exclude remote controllers, it may be understood that the captain is a person on board, so it is still necessary to make changes. Although CSA doesn't refer to

presence on board in the definition of master, many duty andobligations of master could only be performed by people who work on board. From the reply of Canada, we can see that chief controller could not constitute master unless relevant rules are amended.

The rest of the countries answered that their domestic laws did not define "master" or did not answer this question. Most of these countries believe that the master should be a person on board the ship. Unless the law is amended, the chief controller could not be considered as a master. For instance, the Italian Code of Navigation does not bear a specific legal definition of “master”, whereas it envisages an extensive regulation of his powers, duties and obligations.

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

10 MLAs replied that their national laws contain a definition of crew (or seamen) (Bra, Bri, Chi, Cro, Den, Dut, Fin, Fre, Sin, US), among which 9 state that the definition expressly requires on board presence. 8 conclude that the definition could not comprise shore based individuals (Bra, Bri, Chi, Cro, Dut, Fre, Sin, US). Denmark Two MLAs do not exclude that persons working on shore may be “seamen” despite the reference to on board presence (Den, Fin): The Danish MLA states that if an unmanned ship is a ship per definition, a person employed on that ship may be considered a crew member, although de facto not being on board the ship. The Finnish MLA equally states that the definition does not rule out a broader interpretation under which the crew performs its tasks from elsewhere and that focus should be on the functions performed.

2.2.2 Autonomously controlled ship.

The autonomously controlled ship is programmed in advance to follow predetermined courses and achieve preset tasks with no human supervision. The operating system of the ship is able to make decisions and determine actions by itself with the help of precise satellite positioning and self-sensing and so on. The ship react to the changes in its environment including other vessels through commands provided by the algorithms of collision avoidance system. Unlike remotely controlled ship, the autonomously controlled ship is no need for real time monitoring of remote controllers. The pre-programmer is the designer of on-board systems who is not involved with the operation of ship.

From the definitions of master in different national laws, we can see that the common characteristics is that master is in command of the ship during a voyage. Compared with the remote controller, the pre-programmer is in charge of the design of autonomous systems , rather than the operator of the unmanned ship. When the ship is in danger, it is the autonomous system itself that reacts to the situation and make decisions, rather than the pre-programmer. Similarly, the designated person for paper work who is not involved with the operation of the ship is not the person in command of the ship. It is obvious that the chief pre-programmer of an autonomous ship cannot constitute master, let alone the 'designated' person who has no involvement with the operation of the ship.

2.3 Jurisdiction of Flag State, Port State and Coastal State

2.3.1 Genuine link between unmanned ship and flag state

Art.91 of UNCLOS gives states the exclusive power to determine what conditions shall be met to register a ship. It will certainly be involved with the question discussed

above that whether unmanned ship constitute a ship. Except for the condition of on-board crew discussed above, another problem that cannot be ignored is that how to recognize the “genuine link” between unmanned ship and flag state. According to Art. 91 of UNCLOS, the State shall ensure that there must be a genuine link between the State and ships in granting nationality to ships. ”Genuine link” was first referred to in the Nottebohn case. The judgement states that genuine link refers to a real link between naturalized person and naturalized state. Nationality is a legal bond having as its basis a social fact of attachment, a genuine connection of existence, interests and sentiments, together with the existence of reciprocal rights and duties.9 Shortly after the Nottebohm case, L. Kunz pointed out that the real link might be invoked in relation to the nationality of ships. The first time that the "genuine link" was incorporated into international conventions was the Convention on the High Seas adopted at the First Conference on the Law of the Sea in 1958. The provision was improved in UNCLOS later. The United Nations Convention on the Conditions of Registration of Ships, signed in Geneva on 7 February 1986, firstly provides details of the genuine link. For instance, Art. 9 sets a requirement of a satisfactory part of officers and crew of the flag state. Art. 10 asks for representative or management person of the flag state. Eric van Hooydonk holds that the genuine link between the state and the UAV is a complete illusion10. For unmanned ships, the requirement for unmanned ship owners to establish companies in flag countries will hinder the commercial development of unmanned vessels to a certain extent. In addition, unmanned ships will no longer require crew members from remote-controlled operation to full automation. The rules for the crew of the flag state will become

[9] See Liechtenstein v. Guatemala，International Court of Justice，April 6, 1955，General List No. 18

[10] Eric Van Hooydonk, The law of unmanned merchant shipping-an exploration, The Journal of International Maritime Law, p410

meaningless. At last, it is obviously unreasonable for a country to be unable to register a ship if it does not have a autonomou system for unmanned ships. In the future, the principle of genuine link will be null and void that it will be abolished gradually.

UNCLOS not only allows a State to grant nationality to a ship, but also stipulates the obligations of the flag State. According to Art.94 of UNCLOS, flag states shall effectively exercise its jurisdiction and control in administrative, technical and social matters over the ship, its master, officers and crew. For instance, the flag state shall take necessary measure to make sure the seaworthiness of ships. Ships shall be manned to ensure safety at sea. UNCLOS's provisions on the obligations of the flag state are mostly in principle, which are embodied in the relevant international conventions formulated by IMO.

2.3.2 The Right of Navigation under jurisdiction of Port State and Coastal State

Under UNCLOS Convention, all states have the right to establish the breadth of their territory sea . Ships of all states enjoy the right of innocent passage through territorial sea. Except for the flag state, the coastal state and port state have also certain jurisdiction over ships. They could prevent any passage that is not innocent and refuse such ships to enter into their territorial sea. The internal water is also a part of the territory of a coastal state that is different from the territorial sea. The coastal state has the absolute sovereign right of internal water and it can decide whether a foreign ship is allowed to come into the internal water or not. Still, the ship may have the right of innocent passage in certain area of internal water according to Art. 8 of UNCLOS Convention, because some area which should not be supposed to belong to internal water is included within the straight baseline. Here comes to the question that whether unmanned ships have the right of innocent passage in territorial sea and certain area of internal water or not. It can be differed by the purpose of navigation, for commercial

or non-commercial use, such as military objectives. The Article 30 of the UNCLOS Convention says that the coastal state may require warships to leave for the non-compliance with its laws and regulations. That is to say warships may enjoy the right of innocent passage in territorial sea of coastal states. However, this provision causes much controversy. According to the principle of state sovereignty, coastal states have the right to decide whether to allow ships for military objectives to sail into their territorial waters. Currently, unmanned ships are not commonly used for commercial purpose due to lack of capacity to accommodate cargo or passengers.

In the exclusive economic zones, coastal states have the rights to explore, exploit, conserve and manage the natural resources of the waters superjacent to the seabed. Moreover, coastal states have the jurisdiction over matters with regard to marine scientific research, protection and preservation of the marine environment, etc. These rights are not confined to any particular vehivular means, thus the enjoyment of those rights ought not to be diminished because a state seeks to explore its EEZ through, for example, a surveying UUV rather than a conventional ship(Rorbert Veal, Michael Tsimplis&Andrew Serdy, 2019). Therefore, unmanned ships shall have the right of navigation in EEZ of the coastal state. The thing to notice is that the right of navigation of unmanned ships in foreign EEZ shall not violate the laws and regulations of the coastal state.

CHAPTER 3

Difficulties in the application of International Conventions and regulations

There are over 50 IMO international shipping regulations and conventions in force today. The majority of the obligations imposed by IMO regulations are imposed on flag states, and these states must discharge these obligations by prescribing enforceable domestic shipping legislation reflecting the internationally agreed standards(CMI position paper). These conventions and regulations are established on basis of conventional ship, covering requirements for maritime safety, environmental safety, safety of life, etc. There are some contradictions between the laws and regulations established in this way and unmanned ship during the application process. Several obvious difficulties in the application of SOLAS, COLREGS, STCW and MARPOL conventions are analyzed and discussed below.

3.1 SOLAS Convention

3.1.1 Unmanned ship and ship' manning

For conventional ships, ship's manning is the act of arranging a certain amount of qualified crew for ships in order to ensure the safe navigation of ships. It not only requires the total number of crew on board, but also emphasizes the number of crew with competency certificates that must exist on board. This requirement for the number of crew seems to be a greater obstacle and difficulty for unmanned ships to integrate into the current legal framework. In addition to Article 94 of UNCLOS, Chapter 5 of the SOLAS Convention also refers to the standards for safe manning of ships. According to Art.14 of SOLAS, Contracting Government undertake, each for its national ships, to maintain, or if it is necessary, to adopt, measures for the purpose of ensuring that, from the point of view of safety of life at sea, all ships shall be

sufficiently and efficiently manned. Besides, the administration of flag State shall issue a minimum safety crew certificate or equivalent document to prove that the vessel has met the requirement of minimum safe manning. The port state has the right to inspect such certificates or equivalent documents of foreign ships. If the conditions are not in conformity, the competent port state authorities have the right to further inspect and take measures, such as prohibiting the departure of ships until the ship is manned as required. As far as the literal meaning of Article 14 is concerned, its vague expression indicates that the clause does not explicitly require the existence of at least one crew member on board. Here comes the question. What factors should be considered in judging whether the ship has reached the level of safe manning?

The Resolution A. 1047 (27), Principles of Minimum Safe Manning, published by the International Maritime Organization (IMO), has not yet come into force, but it can provide us with corresponding guidance to think about this issue. The rules suggest that flag States should consider such factors as level of automation, degree of shoreside support provided to the ship by the company when determining the minimum manning. The IMO only gives guidance to the minimum manning, so the requirements of the member states may be different. Maritime and Coastguard Agency(MCA) is mainly responsible for the implementation of maritime security policies and international maritime conventions. In order to implement the requirement of safe manning in Chapter 5 of SOLAS Convention, MCA formulated Merchant Shipping Notice (MSN) in accordance with Merchant Shipping Regulation 2015/782. MSN's minimum safe manning is not a mandatory provision, but a "guide document". MSN clearly points out that each ship needs to evaluate its minimum safety manning number separately, related to the degree of automation of the ship. MSN also suggests that the number of safe crew members for new ships can be

negotiated by the shipowner and crew representatives. If the two sides can not reach an agreement after negotiation, MCA has the right to conduct a practical demonstration test to prove whether the ship can sail safely at this level of manning. All these elements seem to support unmanned ships to meet the requirements of safe manning standards. Other countries have adopted stricter regulations on safety allocation standards. For example, the 46 U.S.C. 8301 (a) requires all ships flying the United States flag to be inspected by the Coast Guard to determine whether they are equipped with a professional team. At present, only fishing boats, sailing boats and yachts can not be inspected by the Coast Guard, while other types of ships can not sail without crew on board. Therefore, it eliminates the uncertainty of USC regulations and weakens the discretion of judges. The core purpose of minimum safe manning is to ensure the safety of ships, so it should be "safety" itself to determine the minimum number of crew of a ship. With the development of autonomous systems, ships tend to be remotely controlled and even autonomously controlled.

For remotely controlled ships, flag States can judge whether the ship is safe for its crew members by combining the guidance of Principles of Minimum Safe Manning, the tasks and capabilities of remote controllers, and the equipment and equipment of ships.

For autonomous control ships, the requirement that there must be on-board crew will hinder the progress and development of intelligent technology. Under such circumstances, ship’s manning has no practical significance. It is suggested that special provisions be made to remove the restrictions on ship manning. Flag States can judge whether a ship meets safety standards based on other factors such as the equipment and devices on ship, ship type and ship size.

3.1.2 Unmanned ship and obligation of salvage of life at sea

Maritime navigation is faced with unpredictable risks all the time. The mandatory provisions for rescue of those who are in danger of losing their lives at sea are important measures to ensure the safety of life at sea. After centuries of long-term development, international legislation on the system of salvage at sea includes the Salvage Convention for the Unification of Certain Rules of Law Relating to Assistance and Salvage at Sea, 1910, the Convention on International Salvage, 1989 and so on. The 1910 Convention initially established the principle of "humanitarianism" in the salvage of life at sea. Article 11 clearly states that "every person, even an enemy, who is at risk of life at sea must be assisted by a master". Article 98 of UNCLOS requires that the master of a ship shall rescue any person who is in danger of life at sea. Moreover, if he or she knows that the victim needs rescue, he or she shall go to rescue as soon as possible, in so far as such action may reasonably be expected of him. At the same time, the article also points out that the legal exception of the obligation of salvage is that salvage act will seriously endanger the safety of ships or passengers. The SOLAS Convention again emphasizes the importance of the obligation to salvage in Article 33 of the Chapter V, that is, the master of a ship at sea which is in a position to be able to provide assistance, on receiving a signal from any source that persons are in distress at sea, is bound to proceed with all speed to their assistance, if possible informing them or the search and rescue service that the ship is doing so. From the articles above, we can see thatthe obligation of salvage of life at sea is of greatest significance for masters. No matter who the person in danger is, the master shall rescues him or her. For unmanned ships. Due to the absence of master and crew on board, survivors in distress at sea can not be transferred to safe unmanned ships and emergency rescue can not be provided at the first time.The questions that Whether unmanned ships have rescue capability and

whether they should fulfill their rescue obligations have no clear answers.

For remotely controlled ships, remote controllers are not only responsible for controlling the speed and direction of the ship, but also for receiving the information of the persons in distress transmitted by the ship, and deciding whether the ship should suspend its voyage plan and help the persons in distress. According to the duty and content of the work, the remote operator should be responsible for fulfilling the obligation of life salvage. Due to the limitations of the construction of unmanned vessels, if unmanned vessels should also rescue the distressed persons into the cabin, it is necessary to consider some urgent requirements that the distressed persons may put forward after rescuing the distressed persons into the unmanned vessels. Requirements for heating, medical supplies, adequate food and clean drinking water on board ships if possible.

For autonomous controlled ships, it is difficult to provide assistance to people in distress, because ships follow the pre-set course automatically issued by computer systems. It is pointed out that the ship-owner or charterer of an unmanned ship can not be a reasonable substitute for the master to undertake the obligation of salvage of life in the course of navigation at sea. Unmanned ships will not face many situations of rescuing people in distress. They should be exempted from the rescue obligations of such UAVs, which can even reduce the design and construction costs of UAVs to a certain extent. However, we can't just analyse the problem from an economic point of view. Human being is becoming more and more prominent as the main body of society. The right to life shall be the supreme right because life cannot be measured by money . The duty of life salvage has great social value. If the unmanned ship does not undertake the duty of life salvage, it will not be able to smoothly integrate into the field of maritime shipping.

3.2 COLREGS

3.2.1 Unmanned ship and good seamanship

COLREGS requires the crew on board to take active measures to prevent collision, grounding and other navigation accidents in the activities of navigation, berthing and operation. For instance, according to Rule 8 of COLREGS, any action taken to avoid collision shall be positive, made in ample time and with due regard to the observance of good seamanship. One of the most important rules is rule 2. It requires that due regard shall be had to all dangers of navigation and collision and to any special circumstances even if such considerations may depart from COLREGS rules necessary to avoid immediate danger. Rule 2 emphasizes the value of nautical technology in strict compliance with these Rules. It establishes the principle that in a particular shipping environment, actions in departure from the relevant provisions of COREGS must be taken. For the sake of navigation safety, good seamanship can violate the requirements of COLREGS in a few exceptional cases. In a word, good seamanship is the primary principle of COLREGS, which is more important than other COLREGS rules. According to the shipping history and practice, the crew must be on board to fully assess the difficulties and dangers encountered by the ship at that time and then perform good seamanship. Under the background of unmanned ship, how could good seamanship be performed without crew on board?

For remotely controlled ship, communication equipment makes the interaction between ship and shore instantaneous. Through advanced equipment such as sensors, remote controllers can perceive the specific danger that ships are encountering at sea in real time. If the remote controller has received the necessary training to master professional navigation skills to make judgments and decisions, it does not violate the

original intention of COLREGS to provide good seamanship, that is, to avoid collision and ensure maritime safety.

For autonomous control ships, the preset procedure completely erases the perception and decision-making of human beings. Developers of collision avoidance systems argue that the programming can be designed in such a way that early action would ensure that deviation from COLREGS directions would not be required11. Unmanned Vessel Engineers develop object recognition methods using cameras and sonars. Collision avoidance algorithm at sea. When actions contrary to COREGS should be taken is difficult to achieve through preset procedures, because specific risks can only be known when they actually occur. However, experienced seafarers are also unlikely to be able to take accurate measures in response to any maritime situation. Therefore, both unmanned systems and seafarers with good seamanship make judgments on the basis of their own experience and practice. If in the future, it is not human beings that carry out navigational conduct, it would depend on whether the algorithm used by the navigational system of an unmanned ship is as able as a qualified human being to apply the principle of good seamanship to deviate from rules when necessary. In the view of Netherlands in CMI questionnaire, it would be positive that autonomous operation without on-board crew has an equivalent effect to crew's good seamanship. There is a long way to go for unmanned ships to be fully autonomous. It is too idealistic to rely entirely on technological progress. Hence, in the short term, good seamanship is better not be undertstood literally. As long as remote controllers are able to adequately trained and recognised to deal with special situations at sea, it could seem to be in accordance with the principle of good seamanship.

[11] Robert Veal，Michael Tsimplis. (2017). The integration of unmanned ships into the lex maritima，*Lloyd's Maritime and Commercial Law Quarterly*.

3.2.2 Unmanned ship and proper look-out

According to rule 5 of COLREGS, every vessel shall at all times maintain a proper look-out by sight as well as by hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision. The rule implies that proper look-out needs human perception. Predictions are made by means of visual, auditory by human beings and data received by the electronic navigation assistant system. In recent years, navigation has become more dependent on navigational equipment and devices. The failure of seafarers to look-out or to maintain regular look-out eventually leads to frequent accidents at sea in recent years. There are some disputes about whether the duty of look-out can be replaced by technology for unmanned ships. Some countries believe that technology can replace manual look-out, while some countries believe that technology can not replace manual lookout. Some other countries believe that it is necessary to discuss the situation and treat it differently.

According to the responses of various countries to CMI questionnaire, the United Kingdom, Canada and other countries believe that Article 5 of COLREGS only implies the need for human perception, but it does not specify the need for human perception on board. Therefore, in these countries, technology is very likely to replace manual lookout and Rule 5 will not hinder the application of unmanned ships.

Italy holds the view that neither remotely controlled ships nor autonomously controlled ships can be replaced by manual look-out on board ships. The reason is that proper look-out" in the COLREG is linked with the presence of a human factor as sight and hearing are intrinsic element of the performing of the look-out. The application of radar and other navigational technologies can not relieve ships from the obligation of keeping a lookout at any time by means of human perception. Looking through ship-borne cameras and sonar systems may meet the general requirements of

looking in general sea navigation, but under extreme sea navigation conditions, no one can judge the environment with their own audio-visual on board. Technological equipment is only used to assist or enhance the effect of lookout on traditional ships. Hence it is insufficient to prevent collision risk that only relies on new technologies.

France, Japan and other countries believe that whether technology can replace manual lookout is a technical issue rather than a legal one, which should be discussed at a deeper level. In fact, it depends on the progress of technology to say whether technology can replace manual lookout, for both the remotely controlled ship and the autonomously controlled ship.

For remotely controlled ships, remote controllers can not use audio-visual, but can only rely on ARPA, VTS, ACR, ACASC automatic collision avoidance technology to grasp ship dynamics. The innovation of these technologies is the main determinant of collision avoidance. To a certain extent, this reduces the disappointment caused by human factors, but puts forward higher requirements for the accuracy and instantaneity of information recorded by electronic equipment on board.

For autonomous controlled ships, autonomous collision avoidance system and computer system completely eliminate the inherent shortcomings of human attention deficit or fatigue. The performance of proper look-out depends entirely on the decision of collision avoidance made by the autonomous system after sophiscated analysis of data provided by on-board equipment and devices. Therefore, it is necessary to make additional explanations on Article 5 of COREGS in order to encourage the development of untonomous technology. For the ship without on-board crew, the flag state has the right and duty to test and acknowledge that if proper look-out can be substituted by the systems on ship.

3.3 STCW Convention

STCW desires to promote safety of life and property at sea and the protection of the marine environment by establishing in common agreement international standards of training, certification and watchkeeping for seafarers. Although unmanned ships are not excluded from the convention literally, the Art. 3 expressly regulates that the it shall apply to seafarers serving on board seagoing ships. The Convention stipulates the qualification criteria for masters, senior seafarers and their duty of proper look-out, as well as the lookout procedure. The legal status of unmanned vessel-related staff such as remote controller is not yet clear.It thereby seems clear that its detailed provisions on training and competence find no application in the context of unmanned operations. The most important problem to solve is how to transpose the competency requirements of on-board crew to remote controllers and autonomous technology. When the obligations and duties of crew are transferred to remote controllers, it is also necessary to set the standards of their competency to ensure the safety of ship. When the ship is fully autonomous without human operation, STCW is of no practical significance so that new regulations shall be enacted to ensure the safety of autonomously controlled ships.

3.4 Summary

Based on SOLAS, COLREGS and STCW, this chapter mainly makes an analysis of the relevant provisions of the minimum safety allocation, maritime life rescue, good craft and regular observation.

As for SOLAS, different countries have different opinions on the issue of minimum ship’s manning. Some countries have give a strict explaination of the minimum manning, while other countries believe that the minimum manning can be settled

through consultation between the administration and shipowners. With regard to the salvage of life at sea, this dissertation analyses the duty of unmanned ships separately according to level of automation. Moreover, the ways to fulfill the obligation of salvage of life at sea are discussed seperately for remotely controlled ships and autonomously controlled ships. As for COLREGS, the dissertation analyses how the principle of good seamanship can be applied to two types of ships with different level of automation, insisting that good seamanship is better not be undertstood literally in the short term. The principle could also be acheived by training of remote controllers and improvement of new autonomous technology. Different countries hold different views on whether technology can replace manual look-out. This dissertation holds that the realization of proper look-out for unmanned ships is a technical problem. The innovation and improvement of autonomous technology is the main determinant of avoiding collision. As long as it can be proved that the on-board autonomous system can achieve the desired results by manual look-out，it can be substituted by autonomous technology.

As for STCW，the most important problem to solve is how to transpose the competency requirements of on-board crew to remote controllers and autonomous technology. Due considerations shall be given to the training, certificating, watch-keeping of remote controllers, as well as the relevant requirements of autonomously controlled ships.

CHAPTER 4

Suggestions related to the application of IMO regulations

4.1 Clarify the legal status of the unmanned ship

The ambiguity of ship concept leads to the ambiguity of legal status of unmanned ship. Therefore, perfecting the legal status of unmanned vessels from the legislative point of view is very important to clarify the rights and obligations of flag, port and coastal states. Applying unmanned aerial vehicles to the current legal framework as soon as possible can not only fill the relevant legal gaps, but also help to accelerate the further development of unmanned aerial vehicle technology. From the perspective of the development status of unmanned vessels, the construction of a new law alone may lead to duplication of legislation and may not be able to solve the existing legal conflicts. It is an effective solution to improve the concept of UAV in the existing legal system. Because the international convention covers a wide range of areas and is difficult to adjust the population, IMO can solicit suggestions from various countries on the concept and legal status of unmanned vessels, make specific explanations on unmanned vessels in the light of their functions and levels of automation, add special chapters of unmanned vessels in international conventions, and improve the concept of ships.

4.2 Suggestions related to SOLAS Convention

The progress of unmanned ship technology reduces the risk of ships at sea to a certain extent, and inevitably affects a series of maritime safety standards. In this paper, it is suggested that additional provisions should be made in Chapter 5 on the duty of ship's safety crew and captain to save life at sea. Article 14 may set special standards for the

crew of an unmanned vessel according to its unmanned class. Since the unmanned ship has not been widely operated in the world, it can be temporarily used to determine the number of crew by the way of owner's application and the administration approval, thus forming international practice. Through long-term experience accumulation, the number of crew members of unmanned vessels of different tonnages and types should be summarized, and then the conventions should be revised.

Article 33 stipulates that the captain shall undertake the duty of salvage for persons in distress at sea. Since remote control ships and autonomous control ships are not equipped with captains on board, special provisions should also be made on how these two types of ships can accomplish life salvage at sea. When a remote-operated ship receives a person in distress, it shall promptly send the message to the nearby ship and relevant agencies, and go to rescue or provide rescue assistance. When a fully autonomous ship finds a person in distress, it shall promptly send the message to the nearby ship and relevant institutions. Unmanned vessels shall be equipped with basic rescue facilities, such as lifeboats with positioning functions and necessary survival supplies, and release lifeboats at appropriate times, and monitor the location of lifeboats in real time and send them to nearby ships and related institutions. Unmanned vessels should enjoy the exemption of traditional ships, that is, salvage will seriously endanger the safety of unmanned vessels or passengers on board.

4.3 Suggestions related to COLREGS

As the fundamental clauses of COLREGS, there are some contradictions between good craft and regular sight and unmanned ship's navigation at sea. The relevant provisions should be improved in light of the characteristics of unmanned vessels and their trial voyages. Firstly, Article 2 of COLREGS requires the crew to have good

craftsmanship. Because there are different opinions on whether the remote operator belongs to the crew in the world, this article can supplement the remote operator on the main body of good craft. Similarly, after full consideration of all hazards and the limitations of the ship's own conditions, the remote operator may take actions that deviate from the provisions of these Rules to avoid urgent hazards. Secondly, with regard to regular lookout, the legitimacy of shore lookout and electronic lookout should be determined, and technical requirements for equipment and systems used for lookout should be put forward. Moreover, it evaluates the navigation risk of unmanned vessels, and formulates training plans for remote operators according to the navigation risk, and determines that they can master the basic requirements of shore prospects after training.

4.4 Suggestions related to STCW Convention

由 Since there are different opinions on whether the chief shore remote controller belongs to the captain and other remote operators belong to the crew, it is difficult to define its legal position in international conventions. STCW can be said to be the most contradictory international maritime convention with unmanned vessels, and the amendments to its individual provisions may undermine the rigour of the convention. However, we can draw lessons from the training, certification and duty standards of captains and crew members to formulate separate rules of the International Maritime Convention for remote operators. Firsly, the definition of remote controller shall be defined. Secondly, according to the navigation knowledge and skills that the remote operator must master, the training plan and goal of the remote operator should be formulated. Navigation knowledge and skills should be combined with unmanned ship technology, including the use of software, system control and so on. Thirdly, according to the ability of remote operators, determine their level and scope of work,

and define the scope of work undertaken by different levels of personnel city. Fourthly, the competent authorities of various countries should recognize the level of remote operators according to the results of training or examination, issue competency certificates and register them for the record. Finally, the rule could also be considered for preprogrammers and designated persons for paper work.Take the pre-programmer as an example, the person shall provide written instructions that how the systems work with each other to the flag state. The person shall guarantee the systems have been tested enough times and provide the statistics to prove the seaworthiness of the unmanned ship.

Chapter 5

Conclusion

With the rapid development of unmanned vessels, this paper mainly studies the legal obstacles and challenges faced by unmanned vessels when applying the current maritime legal system. Based on the questionnaire issued by CMI and the responses from various countries, unmanned vessels can be classified as ships that are remotely controlled and autonomously controlled. Firstly, this paper introduces the development and current situation of unmanned ship. Secondly, the legal status of unmanned vessel is analyzed from the definition of unmanned vessel as entrance, and the jurisdiction of flag, port and coastal States over unmanned vessel is studied, mainly involving the relevant content of UNCLOS. Through the analysis of the definitions of ships in international conventions and domestic laws of various countries, it is concluded that the crew is not the constitutional condition of ships and can not hinder the formation of unmanned ships. Although the current legal system has been established under the background of ship ownership, ship is an abstract concept and unmanned ship is not beyond the scope of ship concept. Although unmanned vessels have some application problems in the current international maritime conventions, it does not mean that they are excluded from the existing legal system. If an unmanned ship has the legal status of a ship, it shall enjoy the same navigation power as an ordinary ship, and its flag State shall perform some flag State obligations in accordance with the requirements of international conventions. The genuine link stipulated in the Convention hinders the implementation and development of unmanned ships to some extent. It should be thought over that if the principle of genuine link for unmanned ships shall be applied to unmanned ships.

International conventions on ship safety include SOLAS, COLREGS and STCW.

Because these international conventions emphasize the role of human beings, there are some problems in the application of the conventions. The remote operators of remote control ships play their role in combination with unmanned technology, but fully autonomous ships only rely on complex unmanned technology to complete the voyage, so there are slightly different obstacles in the application of relevant provisions. Finally, in view of the obstacles mentioned above, this paper puts forward some suggestions, including the clarification of the legal status of unmanned vessels and the revision and improvement of the relevant conventions. The clauses mentioned in this paper are only some representative clauses. There are other clauses to be amended, but this article does not discuss them one by one.

The development of unmanned ships can not be separated from the support of technology and market, and also from the support of national policies and laws. To study the legal obstacles faced by unmanned vessels, on the one hand, it can avoid hindering the technological progress of ships, on the other hand, it can lead the development of technology.

REFERENCES

Alexander J. Marcopoulos. (2007). Flags of terror: an argument for rethinking maritime security policy regarding flags of convenience，*32 TUL.MAR.L.J.*

A Severance，S Sandgren. (2014). Flagging the Floating Turbine Unit: Navigating Towards a Registerable, First-Ranking Security Interest in Floating Wind Turbines，*29 TUL.MAR.L.J.*

Cai Yuliang, Ma Jilin. (2017). The influence of the development of unmanned ships on the International Maritime Conventions, *China Ship Survey*.

Craig H. Allen. (2018). Determining the legal status of unmanned maritime vehicles: Formalism vs Functionalism，*Journal of Maritime Law & Commerce*.

Eric Van Hooydonk. (2014). The law of unmanned merchant shipping — an exploration， *Journal of International Maritime Law.*

Eric Van Hooydonk. (2014). Towards a worldwide restatement of the general principles of maritime law, *20 JIML 3*.

Luci Carey. (2017). All hands off deck? The legal barriers to autonomous ships, National University of Singapore.

Michal Chwedczuk. (2016). Analysis of the legal status of unmanned commercial vessels in US，*Journal of Maritime Law and Commerce*.

Paul W.Pritchett. (2015). Ghost ships: why the law should embrace unmanned vessel technology，*Tulane Maritime Law Journal.*

Robert Veal，Michael Tsimplis. (2017). The integration of unmanned ships into the lex maritima，*Lloyd’s Maritime and Commercial Law Quarterly*.

Robert Veal，Michael Tsimplis，Andrew Serdy, (2019). The legal status and operation of unmanned maritime vehicles，*Ocean Development & International Law*.

Shi Wentao. (2017). Discussion on the effect of unmanned vessel to international rules and associated countermeasures, *China Maritime Safety.*

Michal Chwedczuk. (2016). Analysis of the legal status of unmanned commercial vessels in US，*Journal of Maritime Law and Commerce*.

Wang Xin, Chu Beiping. (2017). Legal barriers confronted by unmanned ship under trialing and reaction. *Chinese Journal of Maritime Law.*

CMI Questionnaire on Unmanned Ships, http://www.comitemaritime.org/Maritime-Law-for-Unmanned-Craft/0,27153,115332,00.html.

CMI International Working Group Position Paper on Unmanned Ships and the International Regulatory Framework, http://www.comitemaritime.org/Maritime-Law-for-Unmanned-Craft/0,27153,115332,00.html.

CMI IWG Questionnaire "Unmanned Ships" - GERMANY，http://www.comitemaritime.org/Uploads/Questionnaire%20Responses/20170711-175918-0_Germany.pdf.

CMI IWG Questionnaire "Unmanned Ships" - FINLAND，http://www.comitemaritime.org/Uploads/Questionnaire%20Responses/20170711

-175918-0_Finland.pdf.

CMI IWG Questionnaire "Unmanned Ships" - UK，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/UK%20Response%20to%20CMI%20Questionnaireon%20Unmanned%20Ships.pdf.

CMI IWG Questionnaire "Unmanned Ships" - U.S.，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/20171221-135357-0.pdf.

CMI IWG Questionnaire "Unmanned Ships" - SPAIN，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/unmanned%20craft/Spanish%20Response%20to%20CMI%20Questionnaire%20on%20Unmanned%20Ships.pdf.

CMI IWG Questionnaire "Unmanned Ships" - CHINA，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/unmanned%20craft/CMLA%20RESPONSE%20TO%20CMI%20QUESTIONNAIRE%20ON%20UNMANNED%20SHIPS%20(1).pdf.

CMI IWG Questionnaire "Unmanned Ships" - CROATIA，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/unmanned%20craft/Croatian%20Response%20to%20CMI%20Questionnaire%20on%20Unmanned 20SHips.pdf.

CMI IWG Questionnaire "Unmanned Ships" - NETHERLANDS，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/Dutch%20Response%20to%20CMI%20Questionnaire%20on%20Unmanned%20Ships.pdf.

CMI IWG Questionnaire "Unmanned Ships" - JAPAN，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/JAPANESE%20RESPONSE%20TO%20CMI%20QUESTIONNAIRE%20ON%20UNMANNED%20SHIPS.pdf.

CMI IWG Questionnaire "Unmanned Ships" - SINGAPORE，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/Singapore's%20Response%20to%20CMI%20Questionnaire%20on%20Unmanned%20Ships.pdf.

CMI IWG Questionnaire "Unmanned Ships" - MALTA，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/CMI%20Questionnaire%20-%20final%20clean%20version(854127_4).pdf.

CMI IWG Questionnaire "Unmanned Ships" - ARGENTINA，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/Informe%20al%20CMI%20sobre%20unmanned%20ships.pdf.

CMI IWG Questionnaire "Unmanned Ships" - PANAMA，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/Maritime%20Conventions/Panamanian%20Response%20to%20CMI%20Questionnaire%20on%20Unmanned%20Ships.pdf.

CMI IWG Questionnaire "Unmanned Ships" - ITALY，
http://www.comitemaritime.org/Uploads/Work%20In%20Progress/unmanned%20craft/Italian%20Response%20to%20CMI%20Questionnaire%20on%20Unmanned%20Ships.pdf.