Is UNCLOS Ready for the Era of Seafaring Autonomous Vessels?

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Structured Abstract

Article Type: Research Paper

Purpose—This paper aims to show how the Law of the Sea, guided by the flag system instituted by the United Nations Convention on the Law of the Sea (UNCLOS), presents challenges in regulating automated vessels and how the regulation of the seas should change to deal with the changes in vessels' technology.

Design, Methodology, Approach—The work uses descriptive and analytical research. It builds on existing projects regarding automated vessels to determine their current development. It also analyzes current regulations, confronting the RSE-MASS of the IMO with the reality of automated ships. Finally, it determines whether UNCLOS should change to ensure the effective regulation of this new technology.

Findings—The flag State system provided in UNCLOS is inefficient in regulating automated vessels. Reallocating the regulatory powers of the flag States to the IMO while constituting a worldwide regime over the high seas is a possible solution for successfully regulating automated vessels.

Practical Implications—The proposal of substituting the flag system, one of the baselines of the Law of the Sea, due to the imminent creation of automated vessels.

Originality, Value—This paper shows that UNCLOS was created assuming that the technology involving operations on the high seas will never change. This work deals with the change in vessels' technology to become automated and the issues surrounding their regulation.

Keywords: automated vessels, flag system, *lege ferenda*, UNCLOS

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I. Introduction

The first World's Expo occurred in London in 1851 and became a tradition. The idea was to give the public a peek at what the future of humanity will look like.[1] Isaac Asimov, one of history's crucial sci-fi exponents, wrote a piece on the 1964 World's Expo in the New York Times. He highlighted the current developments while guessing how the Expo will be in 50 years (2014 CE). One of his guesses was that "Much effort will be put into the designing of vehicles with 'Robot-brains' (vehicles that can be set for particular destinations and that will then proceed there without interference by the slow reflexes of a human driver)."[2] Asimov was right in his prediction. Nonetheless, he missed the date by six years. The Expo Dubai 2020, which opened to the public from 1 October 2021 to 31 March 2022, had a whole district where visitors could spot the latest developments in mobility technologies, especially autonomous vehicles.[3]

Also, Asimov's prediction was limited. There are developments in autonomous vessels as well. Multiple companies, States, and organizations are developing technology to build autonomous ships for commercial, transport, and defense purposes.[4]

The legal framework is one of the main concerns regarding technological developments, especially in cases where the regulation was created with the assumption that machinery will not change. This could be the case with autonomous vessels. The Law of the Sea works under the logic of the United Nations Convention on the Law of the Sea (UNCLOS), also called the "Constitution of the Sea," with the assumption that vessels will always need a captain, a flag, and a crew. In other words, they would never be completely automated.

How to face this new challenge? Is UNCLOS ready for the era of seafaring autonomous vessels? This paper states that the regulation based on the current flag State system will not be efficient in regulating autonomous ships. It will do so in three steps. First, it will explain how AI works on autonomous vessels, the current developments in the area, and the challenges of its regulation through the International Maritime Organization (IMO) regulatory exercise on the matter. Second, it will present the inconsistencies between the flag State system and completely autonomous vessels' regulation, concluding that its logic should change. Finally, it will propose a modification to UNCLOS by replacing its flag system with a unified worldwide legal framework, including dispute resolution provisions applicable to both States and enterprises.

II. Autonomous Seafaring Vessels: Technology, Developments, and the Current Approach to Regulation

This section will describe the developments in autonomous vessel technology and the IMO's proposal on how to regulate them. First, it will explain the functioning of AI and deep learning in ships, and it will give examples of the efforts made by States and enterprises to develop completely autonomous vessels. Then, it will comment on the IMO regulatory scoping exercise on Maritime Autonomous Surface Ships (RSE-MASS), which

classified ships depending on their level of automation, deciding not to address possible regulations for completely autonomous vessels.

2.1 The Use of AI and Data Science in the Worldwide Race to Develop Autonomous Vessels

New computer devices work through data science and AI. Data science combines multiple disciplines. First, it employs big data, consisting of all the data stored in an information network fed daily by electronic devices interacting with reality. Second, it uses computer science to develop binary code (sequences of "1" and "0") to unify the information in a single computational language. Finally, it relies on statics to identify the dynamic of the data and make inferences from it.[5] With its application, a computer system can organize data, classify it, and even make predictions after running millions of different statistical scenarios to find the most repetitive occurrence. Furthermore, AI refers to machine learning, which uses data science to allow systems to make decisions while dealing with reality.

For example, the word prediction tool on the keyboards of every smartphone is an application of data science in AI.[6] The tool gathers the rules and words of a specific language, expressed in binary code to predict user preferences. Eventually, the device learns them by repetition and makes better suggestions.

Data science and AI could be applied in as many fields as computational science.[7] Thus, they have become the primary instrument to improve businesses, including the maritime industry. Their broad application simplifies or eliminates human activities in ports and ships. Therefore, the uses of AI and data science range from creating autonomous tools incorporated into a non-autonomous vessel (a boat in its current conception, with a captain and a crew) to developing completely autonomous ships. Several efforts to build this technology could be identified in the private sector, States agendas, and scientific research.

An example in the private sector is Rolls Royce's Advanced Autonomous Waterborne Applications Initiative (AWWA), released in 2016. Its initial schedule is to develop "autonomous unmanned ocean-going ships" by 2035.[8]

Autonomous vessels are on the agenda of the European Union (EU), the United States of America (USA), and China. First, the EU founded the Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) project to research the use of autonomous vessels for commercial purposes.[9] This initiative maintains that autonomous ships will lower the risk of collisions at sea by ten times, besides its apparent profitability compared to the current system.[10] Second, the US Congress approved a budget of 125 million dollars for research on: "long-duration autonomous ship operations" in January 2021. As a result, the US Navy engaged in a 20-year plan with a private enterprise to create a fleet of 120 autonomous vessels and has a project to develop autonomous undersea vehicles for shipment.[11] Lastly, China's technology for crewless ships was already at a stage where it could identify potential risks using cameras, radars, and sensors to assist seafarers in decision-making in 2019.[12]

Finally, there are initiatives to create autonomous vessels to do research at sea. For example, the "Mayflower" is an AI-based ship developed by Promare and IBM. It went through an attempt to cross the Atlantic Ocean from the United Kingdom to the USA in

June 2021. After its first failure to cross the ocean, it was relaunched on 7 September 2021, to resume its testing and scientific research schedule.[13] Finally, on its second attempt, it reached the USA on 5 June 2022, completing the first transatlantic voyage ever made by an automated and crewless vessel.[14]

In sum, machine learning is the primary tool used to improve the maritime industry nowadays. The developments where it is focused could go from creating automated tools for seafarers to completely automated vessels. There are multiple efforts worldwide to change the industry toward the general use of completely autonomous vessels. Thus, regulation is needed.

2.2 RSE-MASS Failure to Recommend a Regulatory Framework for Completely Autonomous Vessels

Given the application of AI and data science in the maritime industry, the Maritime Safety Committee (MSC) of the IMO started the RSE-MASS in 2017 to analyze the effect that the existing regulatory framework would have when facing autonomous vessels. The outcome was passed to the Member States of the organization three years later by circular number 1638 of June 3, 2021.[15] The RSE-MASS classified autonomous vessels depending on their level of automation, identified which will be the main obstacles towards regulation, and analyzed options to amend the IMO Conventions. The findings will be summarized in order.

First, the RSE-MASS identified four degrees of automated vessels: one, ships with some automated operations but that overall seafarers fully control on board; two, remotely controlled ships with seafarers on board; three, remotely controlled ships without seafarers on board; and four, fully autonomous ships.[16] The difference between every degree is the human interference in the ship's voyage since the primary assumption of IMO Conventions, like UNCLOS, is that every boat has a flag, a master, and seafarers on board.[17] Hence, the RSE-MASS relied on this classification for its analysis.

Second, the RSE-MASS indicated three common gaps to be regulated in the IMO Conventions. First, the clarification of the meanings of the terms master and crew, especially for degrees three and four of automation since the Conventions understand that the master and its crew will always be on board the ship. On this matter, it asserts a need to extend or amend the role of the master in the higher degrees of automation.[18] Second, the lack of existence of the term remote-control station in the IMO Conventions and the need to specify its functional and operational requirements for degrees two, three, and four of automation.[19] Third, the role of remote operators as seafarers since they would be in the remote-control station and not in the ship.[20]

The RSE-MASS findings are based on certain assumptions about the future operation of autonomous vessels.[21] There are two which are especially important for the scope of the MSC analysis. First, a human being will supervise the voyage of a degree four autonomous vessel.[22] Second, if the ship is not fully autonomous, it will need a master.[23]

These assumptions catch a glimpse of the scope of the RSE-MASS, which is the understanding that humankind's interference will always be needed for seafaring. Nonetheless, if a ship becomes completely autonomous, there will be no master or preventive human intervention. In this scenario, the machine learning process (software) will use the ship's

technological tools (hardware), such as high-definition cameras, sensors systems, and radars, to determine the decision to be taken in a particular circumstance.[24] Thus, the assumptions limited the RSE-MASS task to the lower degrees of automation in vessel operations from the beginning. In this same line, the RSE-MASS is emphatical to affirm that, regarding the regulation of the higher levels of autonomous vessels, "it seems difficult to determine the most appropriate way at this stage because it might only be found during the discussion on the actual amendments."[25]

Finally, the RSE-MASS recommended developing a new instrument specialized in autonomous vessels.[26] This new instrument would change the common gaps in multiple IMO instruments without the risk of creating more openings or contradictions.[27] In addition to this option, the MSC recommended creating guidelines for an organized transition before the technology is ready.[28]

Nevertheless, if the Member States do not find the first recommendation feasible, the RSE-MASS proposed the amendment of the existing instruments in a high, middle, and low priority order as a second option.[29] For this case, the RSE-MASS classified the current IMO Conventions into four categories. First, those which apply to MASS and prevent their operations. Second, those which apply to MASS and do not prevent their operations. Third, those which apply to MASS and should not prevent their operations but might contain gaps or need to be amended or clarified. Fourth, those which do not apply to MASS operations.[30] So, the MSC suggested that the individualized amendments could start in the first category, excelling the SOLAS Convention, and end in the fourth one by simply making an express statement that the application of these group of regulations will not be affected by autonomous vessel operations.[31]

The MSC clarifies in the Annex of the RSE-MASS that any option for regulation should only address the gaps in IMO Conventions for the lower levels of automation. For the higher levels of automated vessels, it said:

> Autonomously operated MASS certainly will appear in the future. However, for a very long period, the large majority of the world's fleet will still be conventional ships. Therefore, large scale amendments of current regulations only to accommodate MASS operation seem to be unwise, which will also cause confusion and potential barriers for the application of existing provisions to conventional ships.[32]

Thus, the RSE-MASS position is that regulation for completely autonomous vessels will not be needed in the foreseeable future.

This belief might not be accurate for two reasons. First, the efforts made by States, organizations, and enterprises to develop completely autonomous vessels, which were addressed in the last section, could conclude in a jump in the available technology sooner than expected. As exposed in the previous section, the Mayflower already had a successful transatlantic voyage to the USA. Second, regulation for entirely autonomous operations in vessels is already needed because, as the RSE-MASS admitted, a single journey could have different levels of automation.[33]

A voyage at the earliest stages of implementation of degrees three and four autonomous vessels will need three stages: departure, ocean passage, and arrival. The ship will operate autonomously during its course through the ocean, but it will need to be boarded by seafarers before the departure and arrival stages to ensure it comes to port.[34] Strictly

speaking, this scenario will imply that the same vessel could have several degrees of automation depending on the voyage stage. Likewise, the RSE-MASS did not consider questions like the liability in case of a collision between two vessels equipped with a system that will allow them to make an automated voyage on the high seas. This is problematic since, as the example shows, the legal challenges faced by completely automated vessels are the same for vessels with ships passing through the ocean in an unmanned mode, but with the need for assistance in departure and arrival, which are more likely to become a reality in the short run.[35] Furthermore, any recommendation to regulate autonomous vessels should consider full automation.[36]

In conclusion, applying AI and data science in the maritime industry inspired the RSE-MASS. It classified vessels in four degrees depending on their level of automation. It identified three gaps in applying the current IMO Convention to autonomous vessels: the role of the master, the lack of regulation of remote-control stations, and the regime applicable to remote operators. Nonetheless, the RSE-MASS assumed that completely autonomous vessels will always need human supervision, limiting its findings. It also recommended the creation of an international instrument specialized in autonomous vessels under the framework of the IMO to deal with the gaps or an amendment of the IMO Conventions as a second option. To do so, it partially approached the automation of vessels, underestimating the need to regulate completely autonomous vessels, even when it comes to unmanned stages of a voyage, which are likely to be implemented in the short term.

III. Behind the Scenes of the RSE-MASS Limitations: The UNCLOS Flag State System

This section will address the impossibility of effectively regulating automated vessels under the flag State system provided in UNCLOS, using the RSE-MASS of the IMO as an illustrative example. First, it will summarize the current regime. Then, it will highlight the problems it faces in regulating autonomous vessels.

3.1 The Flag State Regulatory Power and the Current Regime of the Law of the Sea

The current regulations on the Law of the Sea will be summarized in two general topics. First are the IMO Conventions' objectives and the relation between the IMO and UNCLOS. Second is the logic behind the flag State system.

The IMO was created in the 1948 "Convention on the Inter-Governmental Maritime Consultative Organization" (IMCO). The IMCO became operational in 1959. However, the Member States decided to change the institution's name in Resolution number A.358 (IX)-IMO in 1975. The change was effective from 1982.[37] This also meant the shift in the 1948 Convention's name, which now goes by the "Convention on the International Maritime Organization."[38] The purpose of the IMO is to provide regulations to be adopted by the cooperation of the Member States regarding international shipping, the efficiency of navigation, maritime safety, and the prevention of pollution.[39]

On the other hand, UNCLOS was adopted in 1982 and entered into force in 1994. The creation process of UNCLOS started with the first United Nations (UN) Conference on the

Law of the Sea, held in 1958. Hence, it took thirty-six years to develop. The IMO was already part of the maritime international regulatory framework when States initiated negotiations to create UNCLOS. Furthermore, the IMO attended the third UN Conference on the Law of the Sea, from which UNCLOS was finally drafted, signed, and ratified.[40]

UNCLOS is understood as the "Constitution of the Sea." It codified the generally applicable rules for States in sea affairs. As part of the constitutional approach to UNCLOS, the IMO has an essential role as a quasi-legislative body that works to implement its provisions, indirectly referred to by the Convention as the "competent international organization" to create regulations.[41] Also, more than thirty-five provisions in UNCLOS refer to rules and standards previously established by the IMO.[42] Thus, the IMO Conventions and regulations work under the frame and logic of UNCLOS.

UNCLOS is divided into XVII parts and IX annexes. Each part contains provisions on specific topics about the treatment of the seas under Public International Law. It provides rules for the territorial sea, contiguous zone, exclusive economic zone (EEZ), and continental shelf as part of the coastal States' sovereignty. Also, it gives common rules for the high seas, such as the principle of freedom of navigation. Finally, it approaches topics such as protecting and preserving the marine environment by creating international obligations for the coastal States in their territories and the high seas.[43] In other words, UNCLOS deals with the jurisdiction of coastal States within their territories and, for specific scenarios, on the high seas.

States must implement specific regulations to fulfill the international obligations they acquired by signing and ratifying UNCLOS. They adopt the minimum requirements developed by the IMO as the competent international organization for the implementation of UNCLOS to do so.[44] Since the IMO Conventions, regulations, and recommendations serve this purpose, they can only work under UNCLOS but not change it.

UNCLOS serves the logic of the classic conception of sovereignty of States under Public International Law. The notions given in the convention rely on the power of States to enforce rules within their territories, the relation between ships from one State in another State's territory, and the relation between ships flying different States' flags on the high seas. It will depend on where the alleged violation of UNCLOS occurred to determine the applicable rules. Therefore, the rule of sovereignty over the territorial sea in Article 2 of UNCLOS is the basis for the whole system. It assumes the coastal States have prescriptive and enforceable jurisdiction for the acts committed in their territories and could control the operations at its sea. Additionally, the rule of territoriality is extended with the flag system to deal with navigation on the high seas.

According to Article 92 of UNCLOS, every ship should fly the flag of a State with which it has a link. The link has been understood as the relationship between the ship and the flag State provided in the national law of the said State. As affirmed by the International Tribunal for the Law of the Sea (ITLOS) in the M/V "Virginia G" case: "The Convention provides in article 91, paragraph 1, that 'every State shall fix the conditions for the grant of its nationality to ships' and does not impose in this regard any limitations on the nationality of ship-owners or crew."[45]

Every ship must comply with its flag State's laws and regulations. In exchange, the flag State should support the boat in case of any situation arising in other States' territorial waters or the high seas. This is how UNCLOS regulates the high seas, which cannot be

considered the territory of any State[46] and are governed by the principle of freedom of navigation.[47] The rule is that a ship should observe the regulations of its flag State anywhere, even on the high seas, since the right of navigation towards them is reserved for States.[48] Thus, the link between a vessel and its flag State prevents other States from acting against that vessel on the high seas. As indicated by ITLOS in the M/V "Norstar" case:

> […] any act of interference with navigation of foreign ships or any exercise of jurisdiction over such ships on the high seas constitutes a breach of the freedom of navigation, unless justified by the Convention or other international treaties. [Also,] […] any act which subjects' activities of a foreign ship on the high seas to the jurisdiction of States other than the flag State constitutes a breach of the freedom of navigation, save in exceptional cases expressly provided for in the Convention or other international treaties.[49]

To ensure uniform legislation for situations arising on the high seas, UNCLOS imposes an obligation on the Member States to meet the international standards set by the IMO by adopting national laws on concerns, like prevention of pollution or safety at sea. The failure to implement the IMO standards implies the international responsibility of the States members to the Convention.

Article 94 provides the duties of flag States under UNCLOS. Their primary and general duty is to "effectively exercise […] jurisdiction and control in administrative, technical and social matters over ships flying its flag." Then, the provision specifies scenarios where the flag State is expected to exercise its control. It should maintain a register of ships flying its flag; exercise jurisdiction over each vessel flying its flag in respect of administrative, technical, and social matters; take measures to ensure the safety at sea of the ships flying its flag and ensure that the master of every vessel is qualified for the task. Number 6 of the referred provision also ratifies the logic behind the UNCLOS framework. Under it, if a State has grounds to believe that the flag State has failed to exercise jurisdiction over a boat flying its flag, the only measure it can take is to report the facts to the flag State, which is supposed to start an investigation on the matter.

In sum, the current Law of the Sea system implements UNCLOS by the Conventions and regulations passed in the IMO framework. Therefore, the IMO works under the same logic as UNCLOS, which system is based on the classic rule of territorial sovereignty, extended to ships by the flag system to ensure their compliance with the Convention regarding activities on the high seas.

3.2 The Obsolescence of the Flag System Due to the New Allocation of Risks on Sea Affairs in the Era of Autonomous Vessels

Since the IMO can only work under the logic established by UNCLOS, the RSE-MASS refusal to make recommendations regarding completely autonomous vessels is not a surprise. Despite the clever but unrealistic statement of not finding it helpful to regulate the degree four automated vessels yet, the MSC emphasis on the difficulties to do it is a hint that the current system is not suitable for this new kind of technology.

As indicated in the last section, the current system works under the rule of territoriality and the assumption that States exercise prescriptive jurisdiction over vessels flying their flags on the high seas. That way, the flag States assure compliance with international minimum standards, as prescribed by UNCLOS, by creating national laws applicable to the

ships flying their flags. This could be better illustrated with an example of the system as it is conceived, leaving aside the challenge of the threshold for the genuine link between a vessel and the State of its flag.[50] The example will assume that the connection between a ship and its flag State is the ability of the State to exercise its jurisdiction after the registry, which has been the threshold used by ITLOS.[51] In more practical words, the flag State law also applies to the owner of the ship, which is commonly an enterprise constituted in its territory.

An Ecuadorian company called "Condor Ltd." buys a cargo ship named "Sweet Mary." After, it registers the vessel in the Ecuadorian registry. Thus, the boat starts flying an Ecuadorian flag. In the meanwhile, the company hires a master and a crew. In the end, Condor Ltd. has everything it needs to start sailing to distant destinations after complying with Ecuadorian national legislation. The company decides to send "Sweet Mary" on its first voyage to China, sailing from the port of Guayaquil, also in Ecuador, with the previously hired Ecuadorian master and crew. Ecuadorian law is applicable at the port and within the territorial sea, given the territoriality principle. Since it flies an Ecuadorian flag, Ecuadorian law will still apply inside the ship when it reaches the high seas.

As it is evident, the most crucial factor of this example is the fact that the owner of the ship needs to meet the requirements to sail under the national legislation of the flag State. Furthermore, it will be liable if anything happens during the voyage since it owns the vessel, it decides when to perform maintenance, and the master and its crew are its employees. At the same time, the flag State will be internationally responsible if the vessel does not comply with minimum international standards or if the State has not pass national laws to make them mandatory. From a Public International Law perspective, the flag system seems natural to human-crewed sailing operations. The State accepts international regulation and then will bind its citizens by passing laws as it finds feasible.

Nonetheless, swapping the "Sweet Mary" for a degree three or four autonomous vessels might also change this conclusion. An example of each will be provided. On one hand, the example for degree three of automation will assume that the IMO adopted the RSE-MASS and there is a convention regulating the matter. On the other hand, the example for degree number four will consider that the convention does not regulate completely autonomous vessels.

In 2025, Condor Ltd. decides to sell the "Sweet Mary" to buy a degree three autonomous vessel, newly offered in the maritime market. The ship was built entirely in the UK, in compliance with the IMO guidelines. Therefore, it has sensors and radars that allow intercontinental voyages without a crew on board, and it was built considering all the regulations on safety and security at sea. Since Condor Ltd. is not a tech company, it hires the services of Wizard Ltd., a company providing services for ships using remote-control centers in States that have adopted the IMO convention on the matter. Hence, Wizard Ltd. will control the ship and its voyage at sea without the owner's intervention. Wizard Ltd. employees will be the ones making the decisions. Condor Ltd. registers the vessel under the name "Drone" in Ecuador, which has no national rules about autonomous vessels.

In this case, Ecuadorian law will apply to the ship within Ecuador's territorial sea and on the high seas. Nonetheless, as the RSE-MASS predicted, it is not clear if the States in which the remote-control centers are located will be substantially interested in the case of an accident on the high seas.[52] In case of an accident, Ecuador could be held responsible for not having assured the proficiency of the decision-makers of the vessel under Article 94 of

UNCLOS, even though the remote-control centers are not in its territory, they have no link with Ecuador, and there could be dozens of them around the world, connecting to the ship depending on its location. Also, the State where Wizard Ltd. is constituted or the States where it has its remote-control centers would be in a better position to assure compliance with the IMO regulations. Nonetheless, they will have no obligation to exercise their jurisdiction under Article 94 of UNCLOS, since the "Drone" is not flying their flags. This will be the first big issue regarding the flag system. However, the example with degree four of automation will present even greater complications for the application of the current system.

In 2035, Condor Ltd. decides to sell the "Drone" to buy a fully autonomous vessel, recently introduced in the maritime market by Rolls Royce. This new type of ship is notoriously more efficient than the degree three autonomous ships and has lower costs for use and implementation, which is why Condor Ltd. sold the "Sweet Mary" from the beginning. The services provided by Wizard Ltd. with its remote-control centers are replaced by machine learning-based software. Also, the ship operates without the need for any supervision. The only foreseeable sunk cost is contracting a person to supervise the ship's operations, according to the assumption of the RSE-MASS that a human being will always supervise autonomous vessels. However, this will not be a realistic scenario since the software will handle the voyage.

On the one hand, the ship is built entirely in the USA, including its hardware. On the other hand, the software installed on the boat is in sync with multiple servers worldwide. It is also being developed and upgraded by machine learning going through all the data and decision-making processes stored in every vessel with the same technology. However, Condor Ltd. will still have to register its fully automated ship in Ecuador under Article 92 of UNCLOS. This time, under the name "The Robot." Other companies worldwide will have to go through the same registration process in many other States.

On its first voyage, now to Korea, "The Robot" is involved in a collision of three completely automated ships. One is a wholly automated oil tanker flying a Swiss flag. The other one is a Korean-flagged shipping vessel. All the ships have the same software installed. After the collision, the oil spills into the ocean, and there is a massive environmental crisis. The reason for the crash is that the software went down worldwide, which at that point in time was a one-in-a-million occurrence.[53]

Using the flag system, the same problem of delocalization of the operations of the ship arises with four-degree automated vessels, but worse. Now, the software operates several automated vessels always interconnected between them at the same time, even though every single one of them might fly a different flag. Also, the software uses different servers distributed worldwide, in connection with satellites.

At this point, the factual matrix seems too complicated to solve using the current logic of UNCLOS. A simplistic response to the given problem could be another assumption. If the current system assumes that when the flag State has a link to a ship flying its flag, it exercises its jurisdiction regardless of the delocalization of the ship's operations and the building of its hardware, the system could keep working as it is.

But then the problem will be the efficiency of the assumptions. To fill the possible gaps in the flag State jurisdiction, as well as in the other possible States involved in a single voyage, the owners of the ship would have to obtain several administrative qualifications and permits, changing as fast as national law changes to add new provisions for the system's

updates. This possible scenario would lower the development of a technology that is likely to change the maritime industry for good, in terms of efficiency and environmental impact. Therefore, it would be against Arts. 192 and 196 of UNCLOS, which provide an obligation of the Member States to ensure the use of the best technological tools available and decrease the environmental impact of the maritime industry.

When completely autonomous vessels are operational, they are expected to become the primary way to sail on the high seas, given their low cost and efficiency.[54] Nonetheless, it is unreasonable to maintain that human-crewed vessels will completely disappear. What is expected is that autonomous vessels change "shipbuilding, equipment, and device, and shipping and port industries […] [and that] [e]specially shipping and port industries form a dynamic ecosystem,"[55] involving autonomous vessels and regular ships.

In this context, commentators have already identified several issues regarding the regulation of autonomous seafaring vessels, as a response to the RSE-MASS but with the flag system remaining unchallenged. One of the most important considerations when addressing the rules that will surround autonomous vessels, and which was already identified in the previous lines, is the apparently inevitable dualism between national and international regulation and the challenges for autonomous vessels regulation arising from their dynamic. Ikroh Yoon has identified the problem and said that it: "would be difficult to secure the effectiveness of enforcement when coastal states exercise jurisdiction [over autonomous vessels.] […] [Likewise,] global society will […] need to review the scope of domestic laws alongside the RSE."[56] In other words, he stated that the regulation of autonomous vessels will always be addressed from the national and international law perspectives. However, as already identified with the example raised in this section, this implicates the overcomplication of the system for autonomous and classic vessels.

To summarize, the current system works under the assumption that a vessel should fly a flag of a State to ensure its compliance with international minimum standards on issues like the operational characteristics of the ship, its safety, and its environmental impact. Therefore, its second assumption is that flag States will fulfill their obligation to adopt IMO regulations. This system is likely to face the problem of delocalization of the operations of automated vessels, which goes against its logic. In this scenario, the way the flag State would exercise jurisdiction over its ships' operations has been accepted as an issue by commentators. In this sense, a reform to the Law of the Sea logic might be needed to regulate autonomous vessels.

IV. UNCLOS in the Era of Completely Autonomous Vessels: Towards a Unified Jurisdiction for Public and Private Sea Affairs

This section will argue for abolishing the flag State system as a possible way to deal with the problem of delocalization of the operations in autonomous vessels. First, it will make a *lege ferenda*[57] consideration about the current system and its efficiency in regulating autonomous vessels. Second, it will propose a general reform to UNCLOS to create a worldwide regime for sea affairs through the IMO.

4.1 How the Law of the Sea Should Be? The Practical Utility of Lege Ferenda *Considerations*

The flag State system seems unfit for autonomous vessels because the jurisdictional power of States is distorted in multiple delocalized operations. The question of what to do is solved depending on what the decision-makers find more worthwhile. In this case, there is a tension between any reform towards efficiency and the prevalence of the principles of autonomy and sovereignty of States instrumented in the flag system.

As it is not shocking, autonomy and sovereignty will prevail against any other goal or value of the international community most of the time. Therefore, considerations of *lege ferenda* are often made when a proposal to change the system might not be suitable under international politics. The complexities of the game of power amongst States make the belief in common goals desirable for the creation of new treaties and regulations. Thus, these considerations are needed in the treaty-making process where the law is a guest in the territory of politics, especially in a specific situation forcing States to provide a solution outside their common framework and rules. This is the case with autonomous vessels. The *lege ferenda* consideration, in this case, would be that the law governing activities at sea should be whatever is efficient, rather than one which ratifies the traditional sovereign power of States.

If States decide their goal is to address the regulation of autonomous vessels efficiently, the system might change. This paper proposes that one way to do it would be to give up on the flag system and constitute a unitary worldwide regime, with dispute resolution and enforcement means, reachable to States or enterprises. This significant change would imply the loss of prescriptive jurisdiction of the States in operations on the high seas in exchange for a more efficient approach.

4.2 UNCLOS and a Worldwide Regime on the Seas

Unlike the current comments on the regulation of autonomous vessels, this paper considers that there should not be different regimes—national and international—for automated and regular vessels. With exceptions for specific scenarios also provided in the applicable rules, all ships should have the same regulation at the international level, regardless of their level of automation. Therefore, the UNCLOS flag system and any other relevant provision in the Convention should be reformed to institute a worldwide regime over the activities of all ships on the high seas. As already stated in the last section, a plea of efficiency over the States exercise of prescriptive jurisdiction.

This work proposes three main ideas for the implementation of a worldwide regime for activities at sea. First, the allocation of prescriptive jurisdiction to the IMO. Second, the creation of a global registry for vessels. Third, the design of a dispute resolution system is to be used by private and public persons to bring claims in sea affairs. These proposals will be addressed in order.

First, the IMO should create unified applicable rules for activities at sea. The decision-making process in the IMO should change by eliminating the provisions that rely on tonnage to give States with bigger fleets a more significant power of decision to pass regulations. Every state should have one vote. Nonetheless, the rest of the IMO decision-making process is already helpful for the constitution of a worldwide regime for two reasons. First,

regulations are approved by member States. Thus, it is a politically viable proposal. Second, the technicalities of new rules are agreed upon in annexes. The approval process works with tacit acceptance, which means that a new set of regulations passes unless one-third of the member states vote against it. Hence, the decision-making process will be efficient. The IMO will create rules regarding activities at sea relating to State-State, State-enterprise, or enterprise-enterprise matters.

Second, a worldwide registry for vessels should be created. This public registry will have information regarding the ship, its owner, builder, and software developer. That way, there will be information about all the enterprises involved in maritime activities. As part of this proposal, the IMO could create rules regarding the activities at sea to simplify the way claims against a ship will be made. At least two ideas could be implemented. First is creating a fund to pay for liability arising from an accident at sea, which is filled by the payments made by all the enterprises involved in sea activities when they contract mandatory insurance. Second is creating a rule providing for joint responsibility of the vessels' owners, builders, and software developers in case of an accident. That way, even in the statistically unreasonable scenario of the occurrence of an accident at sea, the allocation of risks will be efficient.

The creation of worldwide registries is not rare in international affairs. There is one example in Chapter IV of the Convention on International Interest in Mobile Equipment,[58] which provides for the creation of an International Registry for international interests in mobile equipment. There is also one example of national registration that is supervised internationally, which reveals that States might be willing to cooperate in the international arena for registry purposes. Article 2 of the Convention on Registration of Objects Launched into Outer Space (Registration Convention or UNOOSA)[59] provides for the register of every space object launched into Earth's orbit or beyond in the State doing the launch and the duty to inform the Secretary-General of the United Nations of the establishment of said registry. Therefore, the creation of a worldwide register of vessels is feasible.

Third, a new dispute resolution system should be created, allowing the participation of States and enterprises, and covering any possible dispute at sea. This system could be a permanent Court, with specialized chambers located worldwide, or a mixture between judicial bodies and arbitration. All members of UNCLOS will accept the decisions rendered in the use of this mechanism, which will be enforceable in any of them, with provisions for that matter. That way, any dispute regarding sea activities will be efficiently solved. To go deeper into the proposal of a new dispute resolution system, the reform could provide rules for implementing technological tools to go through the proceedings and enforcement. For example, enforcement should be automatic in case of a dispute covered by the found constituted for accidents at sea.

In sum, UNCLOS reform should allocate prescriptive jurisdiction over the seas in the IMO. The IMO would create rules for States and enterprises, regarding activities at sea. A worldwide registry for vessels should be made to ensure complete information on the enterprises involved in activities at sea. Finally, a dispute resolution and enforcement system should be designed to solve disputes between States, enterprises, and States and enterprises.

V. Conclusions

AI and data science are used to automate industries. They are already employed by the maritime industry to automate some of the activities during a vessel's voyage, reducing the crew's workload. Also, they are being applied to build automated vessels. There are efforts worldwide to develop the technology to make completely automated ships operational. For example, Rolls Royce announced its first "autonomous unmanned ocean-going ship" for 2035.

In response to this reality, the IMO started the RSE-MASS in 2017 to make suggestions on regulating automated vessels. The result was rendered to the Member States of the IMO in June 2021. The RSE-MASS classified ships in four degrees according to their level of automation and recommended the creation of a Convention specialized in the matter. It suggested implementing remote-control centers for ships that will be controlled from the coast, extending the definition of the master, and homologating remote operators to seafarers. It also specified that it is not clear if the State where the remote-control center is located will have any substantial interest in an accident at sea and that regulation for uncrewed vessels is at least complex. Finally, it decided to assume that there would be no need to regulate completely automated vessels in the foreseeable future. Thus, it did not make any suggestions for the highest level of automation.

The IMO works as a quasi-legislative body to implement the provisions in UNCLOS, also referred to as the Constitution of the seas. Thus, it cannot go against it when making recommendations or passing new conventions. It will also have to follow its logic, for that matter.

The reason behind the difficulties faced by the RSE-MASS in recommending regulations is the logic of the UNCLOS flag system. The flag system is an extension of the territorial sovereignty of States to vessels flying their flags. It works down the normative pyramid. First, the IMO passes rules to be implemented by flag States, according to Article 94 of UNCLOS. Second, the States implement the IMO rules in their national laws to comply with their international obligations acquired by the ratification of the Convention. Finally, the national law will apply to the vessels flying a State's flag. That way, the system works with the assumption that States effectively exercise their jurisdiction over ships flying their flag.

The flag system might not be compatible when effectively regulating autonomous vessels because of the delocalization of activities at sea that comes with implementing automated technology. In the case of a completely automated ship, it will be owned by the company which made the registration in each country, but it will be software-controlled using machine learning. It is likely that this software would be developed by a third company and connected simultaneously with other vessels using the same system but flying different flags. To regulate this matter under the current system, States will need to pass an overwhelming amount of legislation to assure that all activities at sea comply with IMO rules. Hence, questions about the link between the flag States and the other actors in the delocalization of the activities at sea will be ignored by creating more assumptions to maintain the extension of States' sovereignty over ships on the high seas. Reform will be needed.

To address a possible reform of the UNCLOS flag system, the approach to States should be made using a *lege ferenda* statement: The Law of the Sea should prefer efficiency over the

extension of the principle of territorial sovereignty. In that sense, the flag system should be abolished. States should allocate their prescriptive jurisdiction in the IMO. Therefore, the IMO will create uniform laws for public and private matters at sea. Also, the creation of an international registry will be needed. This registry will contain the information of the ship and every actor involved in delocalizing its activities at sea. Rules like the joint liability of the actors and the creation of an international fund administrated by the IMO in case of an accident at sea will ensure the system's efficiency when addressing claims. Finally, the dispute resolution system of UNCLOS should change to allow State v. State, State v. enterprise, and enterprise v. enterprise disputes. It will also need provisions for the enforcement of decisions in the jurisdiction of the Member States. A change of UNCLOS in this direction, pushed by technological developments, could lead to the evolution of other international law instruments in different matters towards the institution of worldwide systems seeking efficiency in creating and implementing the law.

Notes

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2. Isaac Asimov, "Visit to the World's Fair of 2014," *New York Times*, August 16, 1964, https://archive.nytimes.com/www.nytimes.com/books/97/03/23/lifetimes/asi-v-fair.html?honnan=Nemzeti_Hirhalo, accessed August 26, 2022.

3. Expo 2020 Dubai UAE, "Mobility District," https://www.expo2020dubai.com/en/understanding-expo/mobility-district, accessed August 26, 2022.

4. Infra § 2.2.

5. John D. Kelleher, *Machine Learning: The New AI* (The MIT Press Essential Knowledge series) (Boston: The MIT Press, 2018).

6. Marc Deisenroth, Aldo Faisal, and Cheng Soon Ong, *Mathematics for Machine Learning* (Cambridge: Cambridge University Press, 2019), https://doi.org/10.1017/9781108679930.

7. Longbing Cao, *Data Science Thinking: The Next Scientific, Technological, and Economic Revolution* (Sydney: Springer, 2019).

8. Rolls-Royce, "Autonomous Ships: The Next step," *Rolls-Royce Marine, 2016,* https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/%20customers/marine/ship-intel/rr-ship-intel-aawa-8pg.pdf, accessed August 26, 2022, p. 7.

9. MUNIN is also the name of Odin's raven in Norse mythology. The project chose the name to make a comparison between the technology on unmanned autonomous vessels and the raven, which used to travel around the world without guidance, to deliver its cargo to Odin. See Maritime Unmanned Navigation through Intelligence in Networks. "MUNIN Results," http://www.unmanned-ship.org/munin/about/munin-results-2/, accessed August 26, 2022.

10. *Ibid.*

11. Andy Pasztor, "Forget Self-Driving Cars—The Pentagon Wants Autonomous Ships, Choppers, and Jets," *The Wall Street Journal*, February 13, 2021, https://www.wsj.com/articles/forget-self-driving-carsthe-pentagon-wants-autonomous-ships-choppers-and-jets-11613212200, accessed August 26, 2022.

12. Rui Li, "On the Legal Status of Unmanned Ships," *China Oceans Law Review* 165 (2019), p.185.

13. Live updates on the vessel status could be found in Mayflower Autonomous Ship, "Vessel Status," https://mas400.com/dashboard#live, accessed August 26, 2022.

14. Rob Hig, "The Mayflower Autonomous Ship Has Reached North America: Why This Pioneering Transatlantic Voyage Matters for the Advancement of AI and Automation Technology Across Every Industry," *IBM*, June 6, 2022, https://newsroom.ibm.com/The-Mayflower-Autonomous-Ship-Has-Reached-North-America, accessed August 26, 2022.

15. Maritime Safety Committee of the International Maritime Organization, "Outcome of the Regulatory Scoping Exercise on Maritime Autonomous Surface Ships (MASS)," Circular No. 1638, June 3, 2021 (hereafter RSE-MASS).

16. *Ibid.*, § 3.9.

17. The key IMO Conventions are: (i) the International Convention for the Safety of Life at Sea (SOLAS) 1974, as amended; (ii) the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997 (MARPOL); (iii) and, the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) as amended, including the 1995 and 2010 Manila Amendments. To access the complete list of the IMO Conventions see International Maritime Organization, "List of IMO Conventions," https://www.imo.org/en/About/Conventions/Pages/ListOfConventions.aspx, *IMO,* accessed August 26, 2022.

18. RSE-MASS (2021), § 5.5.

19. *Ibid*., § 5.6.

20. *Ibid*., § 5.7.

21. *Ibid*., § 4.2.

22. *Ibid*., § 4.2, assumption No. 8.

23. *Ibid*., § 4.2, assumption No. 10.

24. Stephen Li and K.S. Fung, "Maritime Autonomous Surface Ships (MASS): Implementation and Legal Issues," *Maritime Business Review* 4(4) (2019), p. 333 (hereafter Li, S., & Fung, K.S.), https://doi.org/10.1108/MABR-01-2019-0006.

25. The exact phrase is repeated thirty-three times over Appendix 2 of the RSE-MASS, which contains the Results of the Regulatory Scoping Exercise at the Instrument Level.

26. RSE- MASS (2021), § 6.2.

27. *Ibid*., Appendix 2, p. 33.

28. *Ibid*., § 6.2

29. *Ibid*., § 6.

30. *Ibid*., Appendix 2.

31. *Ibid*. § 6.6.

32. *Ibid.* Appendix 2, p. 23.

33. *Ibid.* § 3.5.

34. Li, S., & Fung, K.S. (2019), p. 334.

35. Henrik Ringbom, "Regulating Autonomous Ships- Concepts, Challenges, and Precedents," *Ocean Development & International Law* 50(2–3) (2019), p. 163, https://doi.org/10.1080/00908320.2019.1582593.

36. This is without considering the criticism of the RSE-MASS proposals regarding the lack of clarity of its concepts in, for example, the definition of master and crew or the requirements for remote control centers. See: M.C Jo, A.R Lee, Y.D Kim, and J.S Seo, "Study on the Potential Gaps and Themes Identified by the IMO Regulatory Scoping Exercise (RSE) for the Use of Maritime Autonomous Surface Ships (MASS)," *IOP Conference Series: Materials Science and Engineering* 929 (2020). See also: Shiokari, M. and Ota, S. "Considerations on the Common Regulatory Issues Among the IMO Instruments for Realization of Maritime Autonomous Surface Ships," *IOP Conference Series: Materials Science and Engineering* 929 (2020), pp. 5–9, https://doi.org/10.1088/1757-899X/929/1/012014.

37. Robert Beckman and Zhen Sun, "The Relationship Between UNCLOS and IMO Instruments," *Asia-Pacific Journal of Ocean Law and Policy* 2(2) (2017), p. 203 (hereafter Beckman, R., & Sun, Z.), https://doi.org/10.1163/24519391-00202003.

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39. Convention on the International Maritime Organization (1948), Art. 1.

40. Beckman, R., & Sun, Z. (2017), p. 217.

41. *Ibid*., p. 235.

42. *Ibid*., p 221.

43. United Nations, "United Nations Convention on the Law of the Sea," https://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm, 1982, accessed August 26, 2022 (hereinafter "UNCLOS").

44. Beckman, R., & Sun, Z. (2017), p. 228

45. International Tribunal for the Law of the Sea, "M/V "Virginia G" case (Panama/Guinea-Bissau)," Judgment, *ITLOS Reports 2014*, p. 93, para. 323.

46. UNCLOS, Art. 89.

47. *Ibid*., Art. 87.

48. *Ibid*., Art. 90.

49. International Tribunal for the Law of the Sea, "M/V "Norstar" case *(Panama v. Italy)*, Judgment, *ITLOS Reports 2018–2019*, p. 75, paras. 222 and 224.

50. UNCLOS, Art. 91.

51. Referring to the definition of genuine link, ITLOS stated in the "M/V "Virginia G" case (Panama/Guinea-Bissau)," Judgment, *ITLOS Reports 2014*, p. 45, para. 113: "[…] once a ship is registered, the flag State is required, under article 94 of the Convention, to exercise effective jurisdiction and control over that ship in order to ensure that it operates in accordance with generally accepted international regulations, procedures, and practices. This is the meaning of 'genuine link.'"

52. RSE-MASS (2021), "Instrument Casualty Investigation Code," p. 68.

53. For estimations on how autonomous seafaring vessels are likely to impact the risk factor of voyages at the seas in the short term See: Ikroh Yoon, "Technology Assessment on the Astonomous [sic] Ships: Key Findings and Recommendations," *OIP Conference Series: Materials Science and Engineering* 929 (2020), § 3.2 (hereafter Ikroh Yoon), https://doi.org/10.1088/1757-899X/929/1/012015.

54. Damilola Osinuga, "Unmanned Ships: Coping in the Murky Waters of Traditional Maritime Law," *Poredbeno Pomorsko Pravo* 174 (2020), p. 79, https://doi.org/10.21857/y26kec4qd9.

55. Ikroh Yoon (2020), § 3.1.

56. Ikroh Yoon (2020), § 3.3.

57. A consideration of what international law should be, not what it is.

58. International Institute for the Unification of Private Law, "UNIDROIT (2001) Convention on International Interests in Mobile Equipment," https://www.unidroit.org/instruments/security-interests/cape-town-convention/, accessed August 26, 2022.

59. United Nations, "1976 Convention on Registration of Objects Launched into Outer Space," https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introregistration-convention.html, *UNOOSA*, accessed August 26, 2022.

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