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Challenges and Developments in the Public Administration of Autonomous Shipping

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ABSTRACT

This article examines the main trends that exist in the introduction of autonomous shipping within Maritime Industry 4.0, and it evaluates its positive and negative factors. It is noted that the human element will impact shipping in this new model as before, although this impact will change and be transferred to other levels. The legal uncertainties that exist in autonomous shipping are considered herein, and the ways in which these can be eliminated are outlined while taking into account the anthropocentricity of existing international legal instruments for maritime activities, the widespread introduction of digitalization, and the automation of management and communication processes. The international efforts to develop legal standards and administration practices for Marine Autonomous Surface Ships (MASS) reveal a commitment to classical approaches to which new practices are gradually introduced in the development of management systems. This article pays special attention to the changes that have occurred in the public administration of MASS in order to develop a practical approach that is capable of quickly responding to new challenges and threats.

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Introduction

The new technologies of the Industrial Revolution 4.0 (4IR) significantly impact the public administration of shipping. As Kranzberg's (1986) famous first law states, "technology is neither good nor bad; nor is it neutral." Hence, its interaction with social ecology has "environmental, social, and human consequences." Autonomous shipping is one of the best examples of the results of the 4IR, Shipping 4.0, and Maritime Industry 4.0 (Peña Zarzuelo et al., 2020). However, it also currently poses one of the most complex challenges in terms of legal regulations and the formation of best practices in the public administration of shipping (Veal et al., 2019). At the end of 2022, Lloyd announced the certification of the first surface unmanned ship for the DriX system. The ship also received Bureau Veritas approval in principle and represents a significant step forward in the maritime industry's transition towards adopting new autonomous technologies (Grinter, 2022). The issues with Maritime Autonomous Surface Ships' (MASS') security, design features, environmental and social impacts, cyber hazards, and military operations have been discussed in the literature and on dedicated international and national platforms for more than five years. Additionally, ambitious projects in this market were developed by Wilhelmsen and Kongsberg, the start-up Shone, Rolls-Royce (Salyer, 2020), Port Liner (A Dutch company has developed all-electric, fully autonomous cargo barges, 2019), Marin Teknikk (Yara Birkeland, n.d.), and the like. Moreover, the China State Shipbuilding

Corporation commissioned an uncrewed research vessel named Zhu Hai Yun (Zhen, 2023) in January, 2023. The International Maritime Organization (IMO) took over the administration of the development of specific legal norms for MASS, and the leading classification societies and the developers of autonomous ships themselves took responsibility for the technical standards. In addition, unmanned technologies have proven to be very useful during the military conflict in Ukraine (Kurumada, 2023), which has become an additional impetus to the development of new systems (Tsereteli, 2022) as well as the Ukrainian armed forces' assertion that they needed to create a flotilla of sea drones (Ukraine is creating the world's first naval drone fleet: It will be funded through United24, 2022).

Methodology

This paper focuses on the main challenges encountered in the public administration of autonomous shipping and the various means for addressing them. Utilizing global and transnational approaches to the regulation of shipping, this paper discusses the primary issues that maritime administration should address during the introduction of MASS. The authors develop a framework for the gradual unfolding of the regulatory environment for MASS operations. This research is conducted according to a human-centric approach to reforming existing regulations given that MASS and conventional vessels will operate simultaneously

1. Factors Inherent in the Introduction of MASS

Today, robotic systems are responsible for the most detail-oriented and time-consuming processes in which the cost of human error is relatively high. The automation of these processes eliminates the human factor and results in tasks being completed in an easier, cheaper, and more efficient manner. Navigation is no exception to this, although unmanned vessels have yet to be widely distributed, and unified legal regulations are yet to be developed. The applications of robotic systems can be very diverse as they can be used to monitor the state of the environment, aid in saving people and protecting coastal and marine facilities, map narrownesses and other hard-to-reach areas, transport goods, and fight pollution. Unmanned vehicles can also be used in combat operations in which the risk to humans is axiomatic. However, the marine environment is highly unpredictable, resulting in the broad introduction of MASS navigation still needing to catch up to more progressive areas in this respect. However, it worth noting that maritime navigation pioneered the introduction of innovative satellite technologies in management and communication processes. It is expected that artificial intelligence (AI) and 5G technologies will soon be widely demanded in shipping. Therefore, it is time for the marine industry to embrace autonomy, consider how it will influence the industry's future, and the ways in which it can be used in the most efficient manner (Issa et al., 2022). The reluctance to actively use unmanned systems in navigation is due to the industry's traditional conservatism, the long design processes and life cycles of ships, and a high degree of regulation, especially in terms of safety at the national and international levels. Ensuring safety is generally the highest priority and is a topic of great relevance when discussing the development of maritime navigation, including the use of unmanned models, which is facilitated by the significant size of ships, the growth in speeds and traffic intensity, difficult meteorological conditions, and the like.

The primary benefits of introducing MASS include safety, a reduced crew, and increased usable cargo space. Safety is mainly connected to the crew's work onboard. The human element is crucial in maritime safety (European Maritime Safety Report 2022, p. 197) and is a constant concern despite all of the technological advances (Plachkova & Avdieiev, 2020, p. 41). Emergency navigation situations are often caused by crews' mistakes or shipowners' failure to comply with regulations for navigation safety, including a failure to comply with generally accepted methods for the safe management of the vessel and the improper organization of safe navigational watches. As for technical emergencies, their leading causes are non-compliance with the rules for operating marine vessels and their equipment and structures as well as fire safety rules (Gannesen & Soloveva, 2022, p. 66). This is confirmed by the national, regional, and global reports on maritime safety and its main factors. For example, the Maritime Administration of Ukraine, in the document *State of the safety of navigation and accidents on water transport in Ukraine (including outside its borders but with Ukrainian vessels), including small vessels, for January – June 2022 with a cumulative total* (p. 6–11) states that the human factor is the leading cause of emergencies in maritime transport. The 2019 European Maritime Safety Agency's *Annual Overview of Marine Casualties and Incidents* attributed 65.8 % of all maritime accidents to human error (p. 8), while *the Safety and Shipping Review 2022* by Allianz Global Corporate & Specialty indicated that 75 % of shipping incidents involve human error (p. 55). Autonomous shipping is aimed towards reducing the impact of the human factor. However, even when remotely controlling the navigation, this risk cannot be excluded entirely. MASS introduction transfers the human factor to designing, shipbuilding software development, and remote control developments. In addition, enhanced maintenance arrangements are required to remove the risk of incidents caused by systems failures on vessels that are unattended (Ghaderi, 2020).

The complexity of these control systems requires highly qualified employees from development companies to work on or maintain these systems. This complexity also results in low-skilled labor, usually comprising the rank and file of a ship's crew, not being able to assist in these systems' operations. Therefore, those newly entering the maritime industry will be the most affected by the workforce-related implications of autonomous ships (Bogusławski et al., 2022; Polemis et al., 2022). These trends have led to a significant increase in the attention paid to the theoretical and practical training of future industry specialists as well as the efforts made by software developers, specialized educational institutions, and shipowners in terms of unifying these goals in this direction. This shift in attention highlights the importance of the shore crew mastering these professional competencies, which will lead to an unprecedented reduction in the number of crew members on conventional ships as well as a change in their functions (Baum-Talmor & Kitada, 2022). Additionally, these automatic systems have already undergone significant transformations in recent years and are now responsible for the control of modern ships' automation. Some new knowledge and competencies may also emerge in employees, including technological awareness, computing and information skills, learning and self-development, adaptability and flexibility, interpersonal and social skills, self-development skills, and ethical behavior and discipline. Other currently available competencies that will be in demand in the future include soft skills such as teamwork, leadership, communication, and professional language. A technical aspect that has started to recently emerge as important is cyber security and environmental awareness. However, to stay competitive, the crucial skill employees need to develop is "learning how to learn as the learning [in] future workplaces needs to happen in various forms" (Emad et al., 2020).

Testing control systems and MASS involves the creation of high-tech platforms that can recreate possible sailing conditions and long-term tests in the marine environment. It is important to test and verify these systems because, unlike land or air drones, maritime drones are exposed to a much more aggressive environment, work on longer tasks, and have much larger cargo volumes.

The absence of a crew or an understaffed crew affect shipping's economic aspects. The operational costs associated with providing the crew with all the necessary equipment and benefits are usually significant and varied (e.g., wages, insurance, indemnifications related to disability or death). For example, crew salaries currently account for up to 45 % of the total operating costs of a Panamax bulk carrier (Lutz et al., 2017). The crew at sea is much less protected than onshore crews, and there are many more crew members. Due to the reduction of space needed for the crew, the space on the ship that is available for use increases. Thus, autonomous ships are approximately 5 % lighter than crewed ships of similar sizes, and they are able to carry more cargo due to the extra space (Dmitriev & Karetnikov, 2017, p. 1152). In addition, fuel consumption will likely reduce, thereby improving environmental friendliness (Akbar et al., 2020, p. 1741), which will also be facilitated by using clean energy sources for autonomous ships (Issa et al., 2022). Savings can be as high as 40 % by reducing energy costs for heating, ventilation, air conditioning, laundry, and galleys (D 9.3: Quantitative assessment, n.d., p. 41, 42). It is unlikely that passenger liners and fishing vessels will ever become autonomous due to the particular crew duties onboard. However, the absence of a crew on board in some respects may lead to increasing costs due to the need for more complex automation designs, redundance in maintenance practices, and a need for onshore control centers (See Table 1).

Table 1. Costs of Running an Autonomous Ship, adapted from Ziajka-Poznan'ska & Montewka (2021)

Operating Costs	Voyage Costs	Capital Costs
Crew wages (-)*	Air resistance (-)	Deckhouse (-)
Crew-related costs (-)	Light ship weight (-)	Hotel system (-)
Shore control center (+)	Hotel system (-)	Redundant technical system (+)
Maintenance crews (+)**	Boarding crew for port calls (+)	Autonomous ship technology (+)

Note. *Minus sign (–) = a reduction of costs

**Plus sign (+) =an increase.

With all the positive aspects of autonomous surface navigation, there are two major considerations that need to be accounted for in its implementation: Firstly, introducing MASS shifts the roles of autonomous system providers, the shipyards, the shipowners, and the operators in a changing business ecosystem; and, secondly, there is the need for complementary activities, such as those undertaken by ports and shore-based control centers, which necessitate completely new business models (Tsvetkova & Hellström, 2022). The associated costs and social impacts of these aspects are currently relatively unclear.

2. Methods for Overcoming the Legal Uncertainties in Autonomous Shipping

Historically, the legal regulations of navigation and the administration of accepted norms have shown sufficient flexibility and active adaptability to technological innovations. Creating new technologies and improving existing technologies has always been encouraged in the global, regional, and national tools used for administrating the maritime industry. One of the most striking examples was the Safety of Life at Sea's (SOLAS's) widespread containerization or creation of nuclear power plants, which resulted in the emergence of entirely new legal norms and the development of an incentive for developing Port State Control (PSC).

Given the international nature of navigation, the involvement of multinational entities and its legal regulation and public administration in general cannot be an objectively exclusive national matter. This is shown in the existing practice of creating unified norms in this arena.

Additionally, the IMO Member State Audit Scheme's (IMSAS's) auditing of intrastate practices for industry automation and their ensuring the enforceability of norms that are binding also occurs on the supranational level. Therefore, in autonomous surface navigation, the formation of basic and standard rules is expected, and updates and adjustments will likely cover all or most of the usual administrative tools.

There are three basic approaches to the legal regulation of MASS. The first approach focuses on the idea that, due to the lack of dedicated rules, the unmanned fleet is "outlawed." Hence, the introduction of MASS into full-scale operations requires a significant revision of navigation regulations. Therefore, the mass use of robotic cargo ships was recognized as only being possible after the gaps in legal regulation are eliminated (Karetnikov et al., 2016, p. 174). The second approach states that engaging in new activities and developing new technology is lawful but is subject to the general requirements imposed by laws, and the absence of a specific regulatory regime does not necessarily make these activities illegal, forbidden, or restricted (Veal et al., 2019). Thus, the use of MASS is allowed, at least in the form of a test, within the existing regulatory framework. Furthermore, in many cases, regulations may not even be applicable to certain types of MASS. Finally, the third approach suggests that unmanned ship operation is sustainable under the current international maritime legislative framework (Boviatsis & Vlachos, 2022). It asserts that a substantial part of the existing legal framework was drafted when remote control of a sea-going vessel was technologically impossible, so it does not explicitly refer to the physical presence of crew on board. Hence, the applicable terminology (e.g., definitions of a "master," "seafarer," and "shore-based operator") can be redefined, but the main obstacles are the concerns about disrupting existing binding regulations and having a negative social impact (Stępień, 2023). In terms of the latter obstacle, whether or not unmanned maritime vehicles should be regarded as ships should be defined by relevant states' national laws, and these interpretations might be binding on other states in terms of regulating MASS in an orderly manner within existing legal frameworks (Chang et al., 2020, p. 5).

Currently, there may be a significant gap between the time taken to develop and exploit technology and regulators' ability to develop codes and practices, which results in these practices being vulnerable (Kim et al., 2020). This makes the establishment of specific rules relevant and necessary since the effectiveness of shipping can only be demonstrated if the regulations and standards are agreed upon, accepted, and implemented on an international basis first (Sokolova & Cvetkova, 2021, p. 19). To that end, in the absence of specific regulations, public and governmental bodies that oversee the safety of marine activities will normally have the power to authorize the testing and use of emerging technology (Veal et al., 2019, p. 19).

An incomplete list of global international agreements includes the United Nations Convention on the Law of the Sea (UNCLOS), SOLAS, the UN Convention on the Conditions for the Registration of Ships, the International Regulations for Preventing Collisions at Sea (COLREGs), the Standards of Training, Certification, and Watchkeeping (STCW), and the Maritime Labour Convention (MLC). These conventions establish the rules for ships' interactions with coastal structures and other ships as well as the standards for registering ships, training crew members, and keeping watch in addition to the duties of the flag state, and more. The introduction of unmanned ships necessitates a significant revision of their standards from various perspectives: 1) the absence or limited presence of the crew in terms of time and quantity; 2) the regulation of an external dedicated navigator's legal status; 3) the interaction and training of the managing subjects, which are the members of a specific onshore crew; 4) assigning responsibility for the negative consequences of accidents; 5) features of visiting ports and other areas that are subject to intensive navigation (e.g., straits, canals, river communications, etc.); 6) ensuring the safety of navigation in terms of technical equipment and direct operations; and 7) the organization of technical interactions between autonomous ships and coast stations, other autonomous ships, and conventional ships.

Subjective standards are pervasive throughout the UNCLOS, the IMO's regulations, domestic shipping legislation, and civil liability conventions (Roche, 2020). In determining the duties of the ship's flag state and regulating military navigation, the UNCLOS has several rules for the presence of a crew on board a non-military ship (Article 94) and a warship (Article 8). Thus, the presence of a crew on board is presumed. Some researchers believe that whether or not autonomous ships are considered to be conventional ships should be determined by the internal legislation of the flag state (Veal et al., 2019). Indeed, Article 91 of the UNCLOS does not provide for the mandatory presence of a crew in the registration of ships, but it is referenced in the flag states' fulfillment duties (Kuznietsov, 2021, p. 68) on the ship (Article 94), thereby indicating the need for a crew on board a ship in this sense and other international maritime conventions.

It should also be noted that the need to recognize autonomous vehicles as ships at the national level creates conditions that limit the possibility of their operation in specific maritime spaces. This applies to areas under coastal states' jurisdiction. These nations' legislation may have a different view on autonomous vehicles, which may not be recognized by courts in the existing conventions (Belyakov, 2021, p. 65). This is especially true for peaceful, archipelagic, and transit passages. However, Article 42 of the UNCLOS and the prohibition of discriminatory regulation of transit passage in straits used for international navigation should be considered.

Chapter V of the SOLAS (Regulation 14) mandates governments maintaining or adopting measures "to ensure that, from the point of view of safety of life at sea, all ships shall be sufficiently and efficiently manned." The STCW and the MLC focus on ship crews, their training, and ensuring safe watches and working conditions. If crews are temporarily present on autonomous vessels, these tools would most likely be applied to them but would be rarely applied to onshore crews. Hence, updated standards should be considered. For example, some international agreements can extend the term "crew" to include shore-based remote-controlled personnel, or another term could be developed to denote the remote control of autonomous ships (e.g., "coast station personnel", "responsible persons", "onshore controllers", or "remote operators"). Such personnel should be fully conversant with and required to observe the applicable international regulations concerning the SOLAS, the prevention of collisions, and the prevention, reduction, and control of marine pollution (UNCLOS).

An autonomous ship control algorithm must consider all applicable rules of navigation. The state that registers an autonomous ship must ensure compliance with applicable international rules and standards (as detailed in Article 217 of the UNCLOS), which is a precautionary measure against substandard shipping. At the same time, MASS currently can be viewed as substandard since internationally recognized rules for their development are not agreed upon at this level, such as the SOLAS. Regarding Article 94 in the UNCLOS, the communications by radio need to be maintained, the decisions about which will likely be the responsibility of a MASS's built-in algorithm. It is difficult for a non-dedicated MASS to fulfill the obligation of providing assistance to persons in distress at sea (UNCLOS, SOLAS). However, the shore crew may be required to notify the rescue services in the area of the accident and leave an autonomous vessel in the area in case it is needed for the search and rescue operations. Thus, responders can use these vessels as a rescue aid. It should be noted that the SOLAS, like other agreements, does not contain rules on the operation of a coastal command posts, and the rules on life-saving equipment are unlikely to be applied (Shherban, 2020, p. 68).

Another important direction in ensuring maritime safety is the separation and maneuvering of ships, which is within the scope of the COLREGs, which were adopted in 1977. An autonomous ship performs navigational tasks using an autonomous navigation system with the support of a coastal remote-control system. The most difficult challenges for this system are port calls, voyages through areas with intensive shipping, or other navigation difficulties. In addition, any specific or more tolerant application of COLREGs to MASS operations leads to questioning the safety and effectiveness of MASS. For example, allowing MASS to transit under the protection of "Not Under Command," "Restricted in Ability to Maneuver," or any other specific status "would send an underlying message [that] MASS vessels are not as capable, efficient, or as safe as manned ships" (Zhang et al., 2022, p. 10). Hence, there is a dichotomy in that, on the one hand, COLREGs should be appropriately updated for autonomous ships, while, on the other hand, MASS can be widely accepted only if they have the ability to adhere to current collision-avoidance regulations as effectively as any other conventionally manned ship. Furthermore, the COLREGs, as practical rules, are very human-centric as, in many cases, they rely on the decisions and common sense of the officers onboard. As their focus is on preventing collisions at sea, the COLREGs provide objective guidance on vessel priority, but they also allow for subjective deviations from the rules and seamen's ordinary practices if required by the circumstances (Roche, 2020). Thus, there is one major difference between the operation of MASS and the operation of manned ships: The autonomous navigation system may only be able to respond according to predetermined decision criteria and logical sequences, whereas a human operator can improvise (Kim et al., 2022., p. 155). Therefore, it may be quite challenging to apply MASS algorithms to the logic of the CORLEGs and vice versa. Moreover, the adoption of MASS should not disrupt the existing security practices for conventional ships and should not interfere with deck officers' familiarity and comprehensive understanding of the CORLEGs. For example, a survey of licensed deck officers showed that they prefer the original CORLEGs and that they are reluctant to accept major changes. However, there are possible MASS-related amendments that should be made, including:

- adding or clarifying definitions for the relevant terms (e.g., "master," "crew," "the ordinary practices of seamen," "crew ashore," "lookout," etc.);
- adding separate traffic separation schemes that are compulsory for MASS;
- adding an all-encompassing colored identification light for MASS;
- following the principle that no part of the rules should be quantified (Hannaford et al., 2022, p. 262).

The latter point clearly indicates the need to adhere to the CORLEGs' approach in which many of the decisions are based on a human's evaluation of a situation, which is essential for the safety of conventional manned vessels and could simultaneously be the main barrier to the implementation of MASS.

Moreover, an important factor when operating unmanned vessels is considering the current information about the environment. The navigation chart does not contain information about current atmospheric conditions, other navigational restrictions, or any other special conditions. Some of this information can be obtained from hydrometeorological services' summaries, coast guard services, and topographic and radio navigation services, which would be provided as comprehensive information about the intended area of operation (Skaridov, 2021, p. 39).

There are many cyber threats in maritime autonomous transportation, including malicious software that disrupts critical systems and leads to demands for a ransom to restore operations, theft of confidential information, malicious software that disrupts ships' computer systems; intentional disablement or modification of automatic identification system data, such as GPS spoofing (Issa et al., 2022), phishing attacks, and technical and operational problems in the coastal control center. With these threats, equipment requirements, security, and the ability to function under challenging conditions will increase. Furthermore, new challenges can arise. For example, MASS delivers new interrelations between safety and cybersecurity, and their reliance on machine learning and AI creates a threat of adversarial machine learning in the maritime domain (Amro & Gkioulos, 2023, p. 271), which will likely result in changes to some of the functions. The IMO Subcommittee on Ship Systems and Equipment is responsible for these changes, which they make in order to counter such threats.

Another challenge encountered in implementing autonomous ships is that they are expected to exercise jurisdiction in the event of pollution in coastal waters, process, and service ports that requires a change in the Convention on Facilitation of International Maritime Traffic (FAL) regulations, and they are also tasked with implementing PSC procedures in which an authorized agent is most likely to be involved, following protocols for visiting other types of coastal waters or states, and providing shelter, pilotage, and ice assistance. All of these aspects require legal regulation and the creation of mechanisms that will achieve a level of safety that is consistent with the best navigation and administration practices. An interim solution to this obstacle is making bilateral agreements between flag states and coastal states that permit the operation of unmanned vessels (Hogg & Ghosh, 2016).

3. IMO Developments in Autonomous Shipping

The IMO started considering the problems of unmanned navigation in June, 2017 at its 98th session, when the Maritime Safety Committee (MSC) included issues of unmanned navigation on the agenda. In this meeting, unmanned ships were officially given the “MASS” label. At the 99th session of the Committee in May, 2018, MASS was defined as “a ship which, to a varying degree, can operate independent of human interaction”, and a classification of the degree of ship autonomy was proposed:

- “Ships with automated processes and decision support” was the label given to those ships that have seafarers on board who operate and control the shipboards’ systems and functions. Some operations may be automated in this type of ship;
- “Remotely controlled ships with seafarers on board” are ships that are controlled and operated from another location, but seafarers are on board;
- “Remotely controlled ships without seafarers on board” are those that are controlled and operated from another location and on which there are no seafarers; and
- “Fully autonomous ships” are those in which their operating systems are able to make decisions and determine actions independently (MSC 99 – 16 to 25 May 2018 Major Outcomes of the 99th Session of the IMO Maritime Safety).

At the same session, the Committee approved the framework and methodology for a regulatory scoping study and a work plan. The Committee established the Expert Group on Autonomous Courts, which was charged with reviewing the ways in which the regulatory survey was conducted. The IMO’s Strategic Plan (2018–2023) has a key strategic direction towards “Integrat[ing] new and advancing technologies in the regulatory framework.” This involved balancing the benefits derived from new and advancing technologies against safety and security concerns, the impact on the environment, international trade facilitation, and personnel both on board and ashore, and the potential costs to the industry.

At the 101st session of the MSC held in June, 2019, the *Interim Guide for Maritime Autonomous Surface Ships Trials*, MSC.1/Circ.1604, was adopted and approved. This guide emphasizes that proper infrastructure should be established to ensure the safe, secure, and environmentally sound conduct of MASS trials. It also demands the implementation of appropriate strategies to mitigate the effects of incidents and failures of systems, technology, and testing. For example, these strategies should include the ability to respond to emergencies (Article 2.5.1), and appropriate steps should be taken to ensure sufficient cyber risk management of the systems and infrastructure used when conducting MASS trials (Article 2.10).

The IMO's MSC, at its 103rd session in May, 2021, completed a regulatory scoping exercise (RSE) to analyze relevant ship safety treaties in order to assess the ways in which MASS could be regulated. The outcomes of this survey highlighted several high-priority issues that need to be addressed, such as analyzing several instruments that involve the development of MASS terminology and definitions as well as addressing the functional and operational requirements for MASS operations. The RSE indicated that the best way of addressing MASS in the IMO regulatory framework is by using a holistic approach through developing a goal-based MASS instrument. This instrument could take the form of a "MASS Code" and could be used to address the various gaps and themes identified by the RSE (IMO Seminar on Development of a Regulatory Framework for MASS, 2022).

At the 104th session of the IMO's MSC between October 4–8, 2021, several proposals from states for further work in this area were considered in the format of a videoconference. The MSC noted that the best way forward was to address MASS in the IMO regulatory framework, preferably in a holistic manner through the development of a goal-based MASS instrument. This instrument could take the form of a MASS Code that has goals, functional requirements, and corresponding regulations that are suitable for all four degrees of autonomy, thereby addressing the various gaps and themes identified by the RSE. This instrument has a target completion date of 2025. Thus, an integrated approach to forming the future legal basis for MASS was considered to be preferable. Therefore, a single document will define all the primary conditions for autonomous shipping.

The MSC's 105th session in April, 2022 commenced the development of a goal-based instrument that can be used to regulate MASS operations. The MSC approved a road map that includes a work plan for the development of IMO instruments for MASS. The road map envisages the development of a goal-based instrument in the form of a non-mandatory code, with the aim of implementing the first stage in the second half of 2024. Based on the experienced gained in the application of the non-mandatory MASS Code, a mandatory MASS Code will be developed, which is planned to come into force on 1 January, 2028 (MSC 105, 2022).

In September, 2022, the IMO's Seminar on Development of a Regulatory Framework for Maritime Autonomous Surface Ships (the IMO MASS Seminar) took place. This international two-day virtual conference brought together thought leaders from research fields, academia, business, and government to discuss the big challenges and new approaches needed to create the new MASS Code. Combining the MSC, the FAL, and the Legal Committee (LEG), the Joint MSC-LEG-FAL Working Group on MASS was established as a multidisciplinary mechanism to address common high-priority issues identified by the RSEs conducted by the three committees on the use of MASS. The Joint Working Group agreed that a seminar on legal issues, including implications under the UNCLOS, would be beneficial (Safety, legal and facilitation aspects of autonomous shipping discussed, 2022).

Thus, the international legal status of MASS and autonomous shipping has still not been settled and is thus still debated. In addition, establishing mandatory norms in the short term is unlikely. Nevertheless, determining the legal status of MASS, its classification, and the autonomous shipping regime is necessary for observing the legal regulations for the oceans' spaces. The IMO's current focus on autonomous surface vessels is expected to expand into their developing standards and practices for other types of autonomous marine vehicles (e.g., civil and military use, research, and mining). MASS's legal status is fundamental for legitimizing their use in various categories of maritime spaces that are characterized by specific legal regimes (Belyakov, 2021, p. 63).

4. The Structure and Levels Innate to the Public Administration of Autonomous Shipping

Historically, legal regulations were the primary way in which the maritime industry was managed as they influenced the processes of maritime trade, rectified maritime policy directions, and determined the maritime industry's management bodies and their coordination with supranational mechanisms and non-state actors. Modern approaches to public administration provide a comprehensive understanding of regulatory actors, instruments, and tools. The field of maritime activities has several levels: global, regional, and national. State institutions and non-governmental entities (both commercial and non-commercial) interact at these levels. Each of these actors have a specific influence on maritime activities. However, they are subject to the legal standards of the industry, which have stayed the same over the past 40 years. As Roe (2013) noted, current maritime policymaking is essentially static, and its practices are traditional and rooted in historical principles and structures.

The issue of MASS regulation is one example of the gap between traditional standards and new challenges. To overcome this gap, maritime administration needs to gradually move away from imperative foundations by involving stakeholders in a greater capacity in order to generate timely responses to current requests and ensure a dynamic public administration (Dike, 2019). Legislative simplicity, functionality, and non-government governance are post-modern objectives of maritime politics (Duru, 2014, p. 57).

To assess the needs of administrative interference and regulatory environment development, Ghaderi's (2020) two-dimensional approach to understanding the maturity process of the MASS sector was used. The first dimension represents the degree of autonomy, while the second dimension is linked to adoption and the effects that those advancements will have on wider sector dynamics such as ports, shipbuilding, and freight management practices. Thus, the combination of the degree of autonomy and the degree of MASS implementation can provide an understanding of the extent to which a given type of shipping requires regulation as well as the level of these regulations (e.g., national, bilateral, regional, or global). The lower the levels of autonomy and implementation, the less administrative and regulatory interference is required, and it can be implemented at a lower level of maritime administration (See Table 2).

The trends in the public administration of MASS indicate that legal norms have been developed using a traditional approach and that there is a focus on providing comprehensive information on its implementation. However, the impact of public administration's best practices in the 4IR will be unprecedented. The creation and successful testing of MASS show the transition to a new level of manufacturability, autonomy, and innovative AI systems. The COVID-19 pandemic has accelerated the implementation of automation, AI, and big data in all sectors of life (Setyarto et al., 2022, p. 288), and since COVID-19 is now endemic to human society, autonomous ships can be a safe alternative and feasible solution (Askari & Hossain, 2022, p. 40).

Table 2. Two-Dimensional Approach to Regulatory Interference in Autonomous Shipping*

Autonomy degree 4				Industry-wide safety and operational regulations
Autonomy degree 3			Development of international safety regulations	
Autonomy degree 2		Regulation by coastal states		
Autonomy degree 1	Identification of policy and regulatory implications			
	Research and development	**Launch**	**Early adoption**	**Large-scale implementation**

*Note. * = Adapted from Ghaderi (2020), autonomy degree following IMO MSC*

The IMO represents the global level of MASS standards development. The MSC and the LEG agreed to establish a Joint MSC-LEG-FAL Working Group as a multidisciplinary mechanism to address each committee's common issues identified by the RSEs when using MASS. The Joint MSC-LEG-FAL Working Group's first session (MASS-JWG 1) was held remotely in September, 2022. The Joint Working Group developed a table, which was intended as a living document, that can be used to identify the preferred options for addressing common issues, such as the role and responsibilities of a MASS's master and crew, the competencies required for a MASS's master and crew, and the identification and meaning of the term "remote operator" and their duties. A draft work plan was presented for approval by the three committees, which states that the committees will review the report of the first session and that a second Joint Working Group will be convened in 2023 (Safety, legal and facilitation aspects of autonomous shipping discussed, 2022). The complexity and volume of work needed to revise even the central international regulators hinder the creation of the MASS Code, and the orientation of this tool requires considering the design experience of the leading developers and the features of the models they created, which they will most likely not want to share. Therefore, it would be practical to create a platform that can facilitate the discussion of the technical solutions created by the leading developers of MASS and classification societies, thereby allowing for the review of existing and new technical standards. However, the management of risks needs to be discussed in order to avoid industrial espionage.

The interstate level of interaction is represented by the MASSPorts initiative, which is an initiative that aims to collaborate on the development of autonomous ships, and it was created in August, 2020. It united flag, coastal, and port authority representatives from eight countries: China, Denmark, Finland, Japan, the Netherlands, Norway, South Korea, and Singapore. The IMO, the International Association of Marine Aids to Navigation and Lighthouse Authorities, and International Association of Ports and Harbors representatives also participated in the event to create a new conference platform (Eight countries to promote maritime autonomous ship development, 2020). MASSPorts is a network that was formed by like-minded states and organizations to address the challenges and align the standards for the trials and operation of MASS in ports. The network's objectives are to develop detailed guidelines and conditions for MASS trials in port, establish common terminology, form standards of communication, ship reporting, and data exchange to enhance the interoperability of systems across different ports, and facilitate port-to-port MASS trials. Members of the MASSPorts initiative include the China Maritime Safety Administration, the Danish Maritime Authority, the IMO's high-level representative from the Ministry of Transport and Communications, Finland's Maritime Bureau and Ports and Harbors Bureau, Japan's Coast Guard and Ministry of Land, Infrastructure, Transport and Tourism, the Port of Rotterdam Authority, the Norwegian Coastal Administration, the Norwegian Maritime Authority, the Republic of Korea's Smart Shipping and Logistics Division of the Ministry of Oceans and Fisheries, and the Port Authority of Singapore (MASSPorts initiative launched to develop autonomous shipping, 2020). Thus, this platform brings together public actors who have power in the absence of non-state formations. At the same time, combined efforts can show excellent results, an example of which was the World Port Sustainability Program's *COVID-19 Guidance Document for Ports*. These combined efforts can also manifest in joint research and proposals that are aimed towards improving future regulatory frameworks and administrative practices in autonomous shipping.

The regional administration level is represented mainly by environmental instruments and PSC procedures. The existing agreements and the administrative entities that are formed according to these agreements will most likely be informed of updates to the rules and functions for the introduction of autonomous shipping. The regional approach is the approach in which the local legal system and public administration of maritime activities are considered, and the common features arising from the geographical and climatic features of the region can be coordinated. These initiatives can take the form of interaction between government entities, non-governmental organizations, design bureaus, and individual industry experts to develop the most appropriate and applicable autonomous shipping standards.

National maritime administrations are the primary recipients of international agreements. Their functions include the implementation of legal standards and the fulfillment of the duties of the flag states, port states, and coastal states, which includes training and certifying seafarers, registering ships and the flag state control derived from this action, overseeing regional procedures for PSC, organizing search and rescue operations at sea, preventing pollution and controlling its operations, ensuring maritime safety, and more. These administrations are regarded as the official bodies that are responsible for engaging with commercial maritime organizations and other maritime sectors to ensure that the nation's security and safety standards are being implemented. Thus, national administrations guarantee that ships adhere to all of the regulations as set out by the flag state (Administration, 2020).

The IMO assists in these functions through the IMSAS, which started as a voluntary scheme in 2006 and became a treaty obligation in January, 2016. It aims to promote the consistent and effective implementation of applicable IMO instruments as well as assist member states in improving their capabilities while contributing to the enhancement of their overall performance in compliance with the requirements of the instruments to which they are party. This scheme aligns with the industry's system of public administration and Public Administration 4.0 standards. With the introduction of autonomous shipping, this coordination will focus national regulators' attention on the main innovations of the updated shipping practices, allowing for the development of national systems' public administrations according to the obligations assumed by the individual states. Moreover, multi-level cooperation will allow for the development of practices that support the implementation of

Maritime Industry 4.0 by providing comprehensive support to manufacturers and operators of MASS. Autonomous shipping is seen as an important goal for the coming years as *Society and Lifestyles in 2050*: *Insights from a Global Survey of Experts* (Mao et al., 2019) noted the unique role of autonomous vehicles in advancing mobility technology (p. 30) and ensuring environmental conservation (p. 44). However, this approach requires states becoming more involved and governments becoming wiser and more assertive and agile in governing all aspects of public life (Syakrani Bunasim, 2020, p. 21).

Conclusions

In order to develop maritime administration so that it can meet the challenges encountered in autonomous shipping, three aspects should be considered. The first is the legal aspect, which should focus on developing and adjusting regulations. Considering the IMO's integrated approach, this aspect will most likely be accounted for in the MASS Code that will first make recommendations before becoming mandatory, which will occur when it is included in national legislation. The second aspect is the technical one, which comprises the standardization of MASS equipment, specialized software, protocols for the software's support and security, and satellite systems that ensure communication between MASS and control centers according to accepted and globally agreed upon standards. The third and final aspect is the organizational aspect, which includes the creation of national coastal control, maintenance, and repair points or the adaptation of existing port and other communication and repair systems to allow them to work with MASS, the adaptation of berthing complexes of ports for processing MASS, the formation of an audit system for the development and testing of autonomous ships under the auspices of the IMO, and a change in the functionality of international institutions' and areas of cooperations' structural divisions within the regions that can only be divided conditionally due to their isolated existence being impossible. Public administration of these processes is developed on four levels: the global level (the IMO and other global institutions), the regional level (PSC and regional environmental mechanisms), the national level (national legislators and maritime administrations), and the local level (ports or berths, modified customs, and other local legal instruments).

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Лученко Д., Георгієвський Ю., Бєлікова М. Виклики та розвиток публічного адміністрування автономного судноплавства. – Стаття.

У статті розглянуто основні тенденції впровадження автономного судноплавства у рамках морської індустрії 4.0, оцінено його позитивні та негативні риси. Зазначено, що людський фактор, як і раніше, впливатиме на судноплавство у цій новій моделі, хоча такий вплив буде змінено та перенесено на інші рівні. Означено правові невизначеності у сфері автономного судноплавства і шляхи їх усунення з урахуванням антропоцентричності існуючих міжнародно-правових інструментів морської діяльності, широкого впровадження цифровізації та автоматизації процесів управління та зв'язку. Міжнародні зусилля щодо розробки правових стандартів і практики адміністрування для морських автономних надводних суден (MASS) виявляють прихильність до класичних підходів, до яких поступово впроваджуються нові практики розробки систем управління. Особлива увага приділяється змінам, які відбулися у публічному адмініструванні надводного автономного судноплавства з метою розробки практичного підходу, здатного швидко реагувати на нові виклики та загрози.

Ключові слова: публічне адміністрування, 4IP, судноплавство 4.0, морська індустрія 4.0, автономні судна, автономне судноплавство.