JOURNAL OF MARITIME RESEARCH

SPECIAL ISSUE (2026) pp 65–71

ISSN: 1697-4840, www.jmr.unican.es

Autonomous Maritime Systems and International Law: Rethinking Liability and Accountability in The Age of Artificial Intelligence

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ARTICLE INFO

Special Issue:
1st International Maritime and Logistics Conference;
February 10-11, 2026.
National University of Science & Technology (NU), Oman

Article history:
Received 15 Feb 2026;
in revised from 24 Feb 2026;
accepted 05 Jun 2026.

Keywords:
Autonomous maritime systems, Transnational maritime harms, Accountability gaps, Universal jurisdiction, Maritime AI governance.

ABSTRACT

Artificial intelligence (AI) and autonomous navigation technologies are transforming the maritime sector. All these technologies allow navigation, rescue, surveillance, and combat operations of ships with minimal human interventions. This paper discusses the sufficiency of current maritime legal systems in the area of dealing with the liability, accountability and jurisdiction matters related to autonomous navigation. The paper takes a doctrinal approach and an analytical methodology whereby it critically reviews the major international conventions governing maritime challenges. It points the structural constraints within these formations, specifically, their use of human-based assumptions of navigation and decision-making. The review shows that autonomous systems cause accountability gaps related to distributed decision-making by many participants who include shipowners, operators, and technology developers. It also brings out the issues of jurisdiction that come about as a result of cross-border operations and infrastructures that are located remotely. The article finds that current legal frameworks need an effort to curb new risks that exist with autonomous maritime technologies. It suggests a multi-actor liability theory and highlights the necessity of regulatory adjustment, such as the necessity to establish single international standards. Also, the possibility to apply universal jurisdiction with respect to the instances of severe transnational damages. The discovered outcomes are to add to the current discussion of maritime governance through the provision of a model of incorporating technological innovation with legal responsibility.

1. Introduction.

Maritime Autonomous Ships represents an evolutionary technological concept within the modern maritime sector, profoundly impacting the common trends in maritime navigation and ship management. Autonomous Vehicles use a blend of artificial intelligence, remote-control, and sophisticated sensor-based operating systems in executing navigational as well as operational functions without human on board. These inventions provide enhanced performance in operational efficiency, cost-cutting, and safety of the sea. Moreover, it will reduce the chances of human error. However, they create complex legal and regulation issues to international maritime governance. The current international maritime laws were mostly formulated on the background of conventional crewed vessels. This regulatory architecture is challenged by the introduction of the autonomous navigation systems as this replaced new actors of technology in the decision-making process. Consequently, independent maritime activities pose significant concerns in terms of sharing of liability, jurisdiction, and regulatory control. In the event of maritime incidence, the responsibility is likely to be a complex relationship between various players such as shipowners, remote operators, technology developers, and system manufactures. Through these advancements, the use of the available maritime legal principles is complicated. Thus, it calls into question the principle of responsibility attribution in technologically regulated space. It is appreciable to note that various

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conventions and guidelines exist to address these challenges. Even though these initiatives are a significant step in the area of regulatory adaptation, the introduction of universal governance mechanisms is at the initial stage of development. With this background the paper presents the regulatory issues presented by autonomous maritime systems. Moreover, it takes into account the emerging fields of liability thus finding the possible gaps in liability based on real-life examples. To overcome such gaps, this paper suggests a multi-actor liability framework. It also analyses the future use of universal jurisdiction principle in cases where autonomous maritime systems lead to core international crimes.

2. Autonomous Maritime Systems (AMS).

The Autonomous Maritime Systems (AMS) are those maritime platforms that can perform operational, navigational and safety functionalities through automated technologies. These systems integrate some of the advanced technologies like machine-learning, sensor networks, satellite communications, and remote monitoring systems. One of the most important categories of AMS is Maritime Autonomous Surface Ships (MASS). As defined by The International Maritime Organization (IMO), Maritime Autonomous Surface Ships (MASS) are vessels capable of performing without the involvement of human operators to different extents. There are four autonomy levels as identified by the IMO: Firstly, Degree 1 refers to ships with automated process with seafarers on board to control operations. Secondly, Degree 2 includes ships that are operated remotely which have seafarers on board. Thirdly, Degree 3: Remote controlled vessels with no crew present on board. Finally, Degree 4 represents fully autonomous ships, which are able to make autonomous decisions. This categorization is valid as the extent of human intervention defines the applicability of the existing maritime rules. The functioning of autonomous maritime systems in the stage of lower autonomy is usually not incompatible with the system of the traditional laws. The regulatory and liability issues can be much more complex in case of the higher levels of autonomy. Though the autonomous maritime systems in the marine domain includes a wide classification, the deployment of autonomous lethal maritime systems raise the most complex legal issues.

Autonomous lethal maritime systems are considered to be those maritime platforms capable of causing serious threat which grossly violates international humanitarian concepts, meanwhile incorporating AI-enabled operational processes. Such systems can comprise autonomous surface ships, remotely controlled naval platforms or technologies. Also, this may be applied in the maritime defence field by means of algorithmic targeting or engagement capabilities. The conventional weapon systems need constant human guidance and control. Conversely, autonomous lethal marine systems are capable of working on the parameters that are pre fixed. Such systems can also be based on detector configurations to detect targets or environmental conditions. Moreover, machine-learning systems can help them to identify and interact targets. Currently, the vast majority of autonomous maritime systems are aimed at commerce or logistics. Nonetheless, the possibility of introducing autonomous technologies in the field of maritime security or military affairs is causing certain legal issues. The process of defining lethal autonomous maritime systems is crucial because the use or misuse of such technologies can lead to the serious violations of international law. These violations include illegitimate attack of civilian ships, sea terrorism, or a violation of international humanitarian law. Also, responsibility and jurisdiction issues emerge in the application of these systems.

3. Applications Of Autonomous Maritime Systems.

Autonomous Maritime Systems find several applications in civilian as well as military domains. These systems enhance operational efficiency and reduce human intervention. Also, they perform complex maritime functions through automated algorithms. The applications of AMS range from simple automated tasks to complex applications of artificial intelligence which includes:

A. Surveillance and Reconnaissance.

AMS plays a major role in maritime surveillance and reconnaissance through continuous monitoring of vast ocean spaces. These systems are capable of gathering real time data, tracking movements of vessels and detecting possible threats without human intervention. They are particularly useful in border security and monitoring illegal maritime activities. Moreover, they improve the situational awareness indicating the hidden dangers of sea. This application is closely reflected in Autonomous Collision Avoidance System Testing (Japan, 2022). In Japan, the Nippon Foundation held test programs of autonomous ships on the large scale in the context of collision avoidance systems based on AI. In the tests, the vessels were able to navigate through the busy shipping lanes in automated decision-making algorithms. Nevertheless, the experiments revealed that the algorithmic navigation should be under the conditions of the complex reality of the sea. Also, unpredictable human behaviour and environmental factors may affect the vessel movement.

B. Naval Defence Operations and Autonomous Combat Systems.

AMS finds application in military domain. It widely applied in defence operations, including autonomous combat systems. These systems are equipped with algorithmic targeting and engagement capabilities. The use of sensor technologies and data analytics will remain a critical component in defence operations Although, it significantly reduces the human intervention, the concerns regarding accountability, control and compliance with humanitarian law raises significant concerns. The Mayflower Autonomous Ship (MAS) Incident (2021), raised questions regarding the reliability of autonomous maritime operations in critical or defence related context. The Mayflower Autonomous Ship was an autonomous vehicle that was created by IBM and the maritime research partners to carry out an autonomous transatlantic trip. In 2021, when attempting to cross the Atlantic Ocean during its first mission, the ship had a mechanical breakdown, thus halting the mission. Moreover, it has casted doubt on their role in the malfunctioning of the systems in the unmanned maritime operation.

C. Environment Sensing and Monitoring.

AMS is widely used for environmental monitoring. Sonar and radar systems are used for underactivity surveillance. Environmental sensors measure ocean temperatures, marine bio diversity, pollution levels and climate related changes. Also, they facilitate long term data collection in remote sea areas. This enables the system to operate for extended durations. However, the environmental monitoring systems may be affected by technological uncertainties. Errors in autonomous functioning results in unintended environmental consequences. Navigational failures also lead to collision or grounding which may result in fuel leakage affecting the marine habitat and sensitive ecological zones. These situations highlight the technological failures not merely as operational issues but as transnational environmental implications.

D. Commercial Shipping and Logistics.

Autonomous maritime technologies are reshaping maritime cargo transportation and shipping. It has introduced unprecedented levels of efficiency, safety and environmental sustainability. The trend also poses unique challenges such as human errors as well as labour shortages. A significant example in this context is the Yara Birkeland Autonomous Ship (Norway, 2021). The Yara Birkeland was introduced in Norway in an experimental project to create autonomous maritime transport. It is also popularly known as the first fully electric autonomous container ship in the world. The project revealed how automation can be useful in maritime transport. Nonetheless, it also exposed a number of regulatory loopholes. These uncertainties were in terms of certification, operational control and safety regulation. This necessitated the Norwegian maritime authorities to implement some temporary regulatory exemptions in order to get the vessel back to operation under limited conditions. Also, it illustrates the complexities in the application of traditional maritime regulations to autonomous vessels.

E. Submarine Cable Maintenance and Monitoring.

AMS forms the backbone of global communication infrastructure. It has been increasingly used in maintenance and monitoring of submarine cables. These cables can operate efficiently at sea beds and hazardous underwater conditions. It allows efficient fault detection and repair. Also, the system operates with minimal human intervention often traversing international waters. The legal gaps include jurisdictional ambiguity, liability, cyber security and data sovereignty. One incident that highlight the vulnerabilities of submarine cables is the Finland incident in 2024.Here, a Russian oil tanker suspected of causing "aggravated sabotage" after damaging the ESTlink2 submarine power cable.

4. Legal Challenges Of Autonomous Navigation.

Maritime Autonomous Surface Ships (MASS) is a significant issue that is persisting in the present maritime industry. It does not create a legal gap in the realm of international maritime law. Rather, it reveals structural conflicts in maritime governance structures. The existing maritime structures were traditional model of ships controlled by human crew. This assumption is challenged by the autonomous navigation environment, which may operate across multiple jurisdictions. Consequently, in autonomous maritime settings, the establishment of responsibility and the exercise of regulatory control become more complex.

A. Fragmentation of Operational Control

The fragmentation of operational authority is one of the major challenges associated with autonomous maritime operations. Under traditional maritime governance the master of the vessel has the ultimate decision on navigation and safety of the vessel. Autonomous vessels exercise the power of this control by means of Remote Operation Centres (ROCs), automated navigation systems, and terrestrial technological systems. Therefore, functions like route planning, collision avoidance and emergency manoeuvres can be done off-board rather than on the board. Such a decentralisation brings in significant issues regarding the legal aspect of command authority and the determination of actors who are in effective control. Also, in the case of operational activities that are conducted off-board, it is challenging to decide which state has regulatory jurisdiction.

B. Accountability Gap and Distributed Decision-Making

Another challenge associated with conventional maritime liability systems is autonomous navigation. Autonomous vessels rely on several networked technology systems. Thus, the cause of maritime incidents can be the interplay of various technical factors rather than the individual human factor. Breakages can be due to software malfunctions, sensor mal interpretation, slow remote response or cyber-attacks on control systems. This technologically enabled causes make attribution of responsibility more difficult in the legal systems that are conventionally based on the identification of a proximate human cause. Therefore, liability can be distributed among various actors of autonomous operations, such as shipowners, remote operators, software developers, equipment producers, and certification agencies.

C. Human-Centred Regulatory Norms

Another issue arose with respect to the human centric design of the current maritime regulatory tools. Ensuring the enforcement of international laws and conventions like the COLREGs, SOLAS, STCW remains difficult, especially when dealing with autonomous decision-making systems. These agreements were drafted based on the premise that effective navigation depends upon trained seafarers of sound professional judgment. As an example, COLREGs mandates that the vessels should have a proper watch on sea, calculate a safe speed, and act substantially to prevent the collisions. Autonomous systems can function similar to the work of navigational systems via sensors and algorithmic modelling. Still, it is not clear whether the systems can meet the standards that are defined in the context of human judgement.

D. Sovereignty and Jurisdictional Challenges

There are also serious jurisdictional challenges in the sovereignty - based framework of International maritime law concerning autonomous shipping. The longstanding maritime governance assigns power between flag states, coast states, and port states according to the well-defined territorial and jurisdictional principles. This structure is complicated by the fact that autonomous vessels can perform operational in various locations simultaneously. A ship can be deemed flagged in a particular state with its control centre in a different state. Also, it passes through the territorial waters or the exclusive economic zone of another state. This decentralization of the operation leads to some significant issues about the distribution of the responsibility of regulation between the states. Although flag states still have the major jurisdiction over ships on the high seas, coastal and port states establish jurisdiction within their respective maritime jurisdictions. In the case the operational command is performed by remote infrastructures, which are not located on the territory of the flag state, the concept of effective control is even less determined. There are also issues of digital sovereignty that are brought about by autonomous navigation. These ships are based on satellite guidance, web-based data processing, and algorithm decision-making systems which could be operated by technology suppliers based in other jurisdictions. Consequently, the question of who holds the regulatory power in the technological systems that inform the decision-making processes in navigating arises.

E. Cybersecurity Risks

The autonomous ships are very dependent on computer networks, such as satellite navigation, remote control communication networks, and cloud-based data processing systems. GPS spoofing, signal interference, system intrusion, and ransomware attacks are examples of cybersecurity problems that AMS faces due to this technological dependency. The cyber interference can lead not only to technical failure but also to other severe maritime accidents, such as the loss of navigation, crashes, grounding, or pollution. Such risks are caused by weaknesses in digital architectures, as opposed to operational errors, in autonomous operations.

Cybersecurity thus becomes an inherent part of maritime safety regulation. It needs to be included in the international regulations. Cyber-induced incidents may include as much as liability may be allocated to software developers, system designers, and other parties that maintain cybersecurity measures other than that of shipowners or vessel operators. These risks are already being dealt with by international regulatory institutions. The International Maritime Organization passed Resolution MSC.428(98) on Maritime Cyber Risk Management to ensure cyber risk management is integrated their safety management systems. Moreover, it emphasised that the issue of cyber risk must be considered by shipping companies as part of the International Safety Management (ISM) scheme.

When applied to the context of autonomous vessels, all of these measures are especially important. The safety of the operations relies upon the integrity of navigation systems and remote communication networks. The traditional maritime safety systems were not created to handle digitally induced threats. They do not handle a scenario where the liability is complicated and thus shared because of cyber-attack. Moreover, vessels that have the autonomous system when sailing in various maritime areas are susceptible to cyber interception. These attacks may introduce a problem of jurisdiction. These complications occur when the vessel, the operator, the data servers and the states that are involved situates in various jurisdictions. In severe cases, autonomous vessels that are attacked with aggression on the Internet would facilitate illegal acts of violent attacks on civilian vessels. These are situations that may cause a violation of international law. In certain cases, they may even constitute war crimes or crimes against humanity when they result in mass destruction of the civilian population or sea transport infrastructure.

F. Environmental Risks

The environmental threats of autonomous shipping could be an issue of navigational failure, failure of the system, or a cybersecurity attack. These threats might be resulting in a collision or the leak of dangerous chemicals. The obligations are not affected by the fact that the onboard crew is not present. However, self-regulating activities present feasible issues to the enforcement of the current regulatory frameworks. MARPOL provisions tend to presuppose the use of a crew that would oversee pollution control mechanisms thereby reacting to environmental crises. The ships that are run without staff onboard rely on system of automation for emergency management and compliance measures. These advancements imply that regulations should be updated to make sure that autonomous ships align with existing environmental protection rules. Environmental control might have to be increased to avoid pollution across the globe. This could necessitate the use of modern surveillance systems. It can include enhancing the standards of technology reliability and cybersecurity protection. Moreover, cases of pollution by autonomous vessels may be a source of jurisdiction issues. These are problems that occur when there is an operation, control, or regulation of the vessel by different states.

5. International Legal Frameworks.

AMS is regulated in accordance with current international maritime law. The existing legal framework governing AMS is fragmented across many international conventions. Moreover, there is no single comprehensive document to govern the unmanned maritime systems. The major international legal frameworks are as follows:

A. UNCLOS

The key legal framework to regulate the naval activities is the United Nations Convention on the Law of the Sea (UNCLOS). The framework of jurisdiction on which Maritime Autonomous Surface Ships (MASS) is provided by this convention. UNCLOS creates the legal framework of the seas through assigning zoning of the sea. Also, it provides for the powers and liabilities of the states towards navigation, environmental conservation, and sea governance. Moreover, the Convention was supposed to be a holistic legal system to cover all matters regarding the law of the sea. It implies that the Convention can be interpreted to suit new maritime technology like the autonomous vessels. One of the main characteristics of this framework is flag state system.

According to Articles 91,92,94 of the United Nations Convention on the Law of the Sea, all vessels to sail under the flag of one state, and on the high seas under the exclusive jurisdiction of the flag state, which is further provided to exercise effective jurisdiction and control in the administrative, technical and social issue. This has involved adherence to internationally recognised safety and environmental regulations through vessel registration, silencing regimes, and inspection processes. Moreover, the international system of maritime governance is based on these obligations. The advent of autonomous maritime technologies demands a thorough re-evaluation of the control mechanisms. Regulatory control is more complex than conventional scope in systems where automated systems are involved in performing navigational functions. It may extend beyond the traditional control over the onboard crew and vessel operation. In this regard, successful jurisdiction can also entail monitoring of technological systems, digital infrastructures and operational networks that affect the operations of autonomous vessels.

In addition to the obligation of the treaty enshrined in the UNCLOS, the United Nations has repeated demand for have safe and sustainable maritime governance. Several resolutions have been passed in this regard. The United Nations General Assembly Resolution on Oceans and the Law of the Sea emphasizes the state responsibilities. It provides that countries must ensure emerging maritime technologies operate in accordance with international law. This obligation is particularly important as new technological systems are increasingly used in maritime activities. States must also ensure that these technologies do not undermine the objectives of safety and environmental protection established under UNCLOS. The resolutions reinforce the continuing position of flag states. They point out that it is necessary to maintain appropriate control over the vessels within their area of jurisdiction. This is the case even when even vessels that use sophisticated autonomous technologies are being operated.

B. IMO

The International Maritime Organization (IMO)is the specialized agency of United Nations. The organization is in charge of regulating the maritime sector also, it has been tasked with the development of technical and operational standards. These standards are directed towards ensuring maritime safety and protection of the marine environment. Also, is responsible for adapting international maritime regulations to the changing world of technology. This includes the emergence and development of Maritime Autonomous Surface Ships (MASS).In response to these developments, the IMO has undertaken regulatory efforts to devise a regulatory framework for autonomous shipping. One of the major efforts in this direction is the creation of the Maritime Autonomous Surface Ships Code (MASS Code) which is expected to develop international standards for the design, building and operation of autonomous ships. The MASS Code is currently planned to operate in a non-mandatory manner, where it may transform into a binding one in the future. Until such regulatory standards are formally adopted, autonomous vessels continue to operate in the framework of existing maritime conventions developed for conventionally crewed ships. The development of this regulatory framework has been guided by the Regulatory Scoping Exercise for Maritime Autonomous Surface Ships of the IMO Maritime Safety Committee. This exercise focused on what extent the provisions of existing international instruments apply to autonomous vessels. It also determines the areas where clarification or a regulatory adaptation might be necessary. They have assisted in the further evolution of the MASS Code. Moreover, they play an important role in ensuring that autonomous technologies are safely integrated into the global maritime regulatory framework.

C. SOLAS

Another major international regulation that control maritime safety is the International Convention of Safety of Life at Sea (SOLAS). It sets standards regarding the construction and equipment of vessels. It also establishes operational procedures to guarantee the safety of life at sea. Nevertheless, most SOLAS provisions were formulated on the assumption that vessels have crews on board. These crews are expected to respond to emergencies also to carry out navigation duties. The increased maritime autonomy is a concern to this supposition. Some of the SOLAS requirements are based on the assumption of existence of manpower to carry out manual tasks, like steering the ship or addressing emergencies in the ship board, e.g., fire or evacuation. In cases where ships can travel without crew, making use of such provisions becomes less clear. However, the control of autonomous ships is still under the authority of the current SOLAS framework. But this framework might need an interpretative clarification. It can also need regulatory modifications to allow remote operation centres and automated safety systems.

D. STCW

The International Convention on Standards of Training, Certification and Watchkeeping of Seafarers (STCW) provides worldwide principles on the application, certification, and training competency of seafarers. The initial purpose of the convention is to promote maritime safety through making sure that the members of the crews have the professional skills required to keep the vessels safe. Nevertheless, the advent of autonomous ships that do not need a crew in the cabin gives the current STCW framework a problem. The convention now concentrates on training and certification of the seafarers who are physically on board the ship. It does not specifically acknowledge remote operators or personnel operating autonomous navigation systems in the shore control centres. Consequently, there is still no internationally agreed system of certification of competence and qualification of remote operators that are in charge of autonomous vessels. This regulatory gap could be filled by broadening STCW and adding new professional functions to it, e.g. remote navigators and autonomous system oversight.

E. COLREGs

The International Regulations of Preventing Collisions at Sea (COLREGs) forms the basic navigation regulations that are imposed to avoid collisions of ships. These regulations are applicable to vessels that are on the high seas as well as other waterways that can be navigated. Also, they are considered a fundamental element of the international maritime safety regime. However, most of the provisions of COLREGs are dependent on human judgement and seamanship. The important are Rule 5 to Rule 8 that requires proper look-out of vessels, maintain safe speed, identify the risk of collision and take action to avoid collision. They demand that the navigators take situational decisions based on experience and professional judgement. Autonomous vessels can carry out navigational functions with sensor technologies and algorithmic modelling, but how these rules can be applied to algorithmic decision-making systems is not clear yet. Also, the question of whether autonomous navigation systems are up to the standards according to human judgement is a complex issue. Moreover, it creates an opportunity to clarify its regulatory aspects within the changing paradigm of autonomous maritime regulation.

Despite these developments, the existing legal frameworks are not sufficient to regulate AMS efficiently. With the rapid advancement of autonomous technologies, there are significant gaps in attribution of accountability, jurisdiction and enforcement. There should be a unified international regulatory framework to address these challenges.

6. Governance Framework For Mass.

A coordinated system of governance is required in order to overcome such challenges. Such a structure must combine technological innovation and the set of legal principles. The framework should:

Firstly, the study of the jurisdiction must be built around the concept of effective operational control especially where remotely operational infrastructures are used to execute the navigational decisions. Under these circumstances, regulatory control can go further than the registration of vessels to cover the control of technological systems and functioning networks.

Secondly, the division of liabilities should correspond to the ability to control the creation of risks in the technological environment. Shipowners, remote operators, technology developers and regulatory authorities each have separate functions which can lead to legal responsibilities. This model holds parties responsible based on their ability to create risk. Shipowners still have the major responsibility since they decide on the use of autonomous technologies. Also, they have the control over vessels. When remote operators are monitoring the navigation and addressing system alarms, they are undertaking similar tasks to those of a ship master. Software developers and manufacturers are in a position to assume responsibility in the occurrence of system crashes due to defects in design, algorithmic errors, or improper safety testing.

Thirdly, autonomous navigation should have mechanisms in place that guarantee transparency and traceability of technology. The autonomous decision-making systems must ensure safe data storage, logs and audit trails that are potentially useful both in regulatory control and resolving disputes.

Lastly, the creation of a risk-based certification system would enable the regulator to test the safety and reliability of autonomous systems before deployment. This practice may be used as an addition to future regulatory tools including the IMO Maritime Autonomous Surface Ships (MASS) Code.

Although the above parts are mainly on regulatory and civil liability, the use of autonomous maritime systems which have the capacity to use lethal force. This might also present issues concerning the international criminal responsibility. The concept of universal jurisdiction of international law is such that it allows any state to exercise criminal jurisdiction over specific core crimes irrespective of the place of commission, the nationality of the offender, and the nationality of the victims. The doctrine is conventionally defended using the justification that there are certain crimes which are so grave to the extent that they impact the entire international community (jus cognes) creating erga omnes obligation. Historically universal jurisdiction had evolved with regard to the piracy jure gentium. The high sea pirates were referred to as the enemies of the entire humankind, therefore be prosecuted by any state that caught them. The concept of universal jurisdiction over time came to cover other severe international crimes like the acts of genocide, crimes against humanity, war crimes, and torture.

Universal jurisdiction can potentially gain a new face in the case of autonomous maritime technologies in which autonomous or remotely controlled maritime systems can cause lethal damage. The launch of autonomous maritime platforms with weapon systems or the ability to execute military actions increases the prospect that they would be utilized in a manner that contravened the international humanitarian law or other basic norms of international law. Self-driving technologies are more frequently implemented in the military and naval systems. Among such examples, there are naval autonomous drones that can perform surveillance operations or attack operations, autonomous sea mines that can detect and attack vessels on their own, and artificial intelligence-assisted targeting systems that can be used during combat platforms in the navy. These technologies are based on the algorithmic decision-making and analysis of sensors in order to detect potential threats in the maritime setting. Although these systems can increase military capacities, the application of these systems gives great concern in the area of international law of humanity. Also, it is necessary to apply the principles of distinguishing, proportionality, and precaution in regard to attacks. In case the illegal assaults on civilian ships or the safeguarded individuals on the ocean were executed by autonomous maritime systems, the resultant behavior might be considered a war crime under the international law. To illustrate, in case an autonomous maritime platform performed an illegal attack on civilian ships, a targeted assault on civilian vessels, or committed other maritime terrorism-related actions, this might be regarded as war crimes or crimes against humanity. Here, the criminal responsibility can go beyond the person at the physical level of the functioning of the system. It may also apply to commanders, programmers, system designers, manufacturers, or even state authorities, whose actions authorise the use of the autonomous platform. Autonomous systems are based on the distributed technologies, remote operation centres and algorithmic decision-making. They operate also on the cross-border digital networks. These features render it hard to establish the geographical location of crime. Such dispersion of operational control may make it difficult to apply the conventional jurisdictional principles like territorial or nationality jurisdiction. Under this condition, the last resort is the universal jurisdiction. It ensures that serious international crimes are not unpunished by using autonomous maritime systems. The doctrine acknowledges that some crimes are threat to the international legal order. Thus, it enables any State to prosecute those individuals who commit most serious international crimes.

Conclusions.

The advancement of autonomous maritime systems remains a critical issue within the maritime industry, driven by various factors such as liability of various actors, complex jurisdictional structures and weak regulatory enforcement. The autonomous technologies often operate within weak regulatory frameworks as they are traditionally targeted for conventional crewed ships. The lack of universal accountability mechanism further exacerbates this problem. The complexity of autonomous control structures with ships often controlled from different jurisdictions complicates efforts to hold any single entity accountable for the crimes. This uncertainty leaves automated navigational systems vulnerable, as seen in numerous real-world instances. The use of algorithm base navigation systems further complicates the issue by introducing new forms of operational and legal risks. To improve this situation the formation of regulations like IMO MASS Code, addressing legal loop holes and increasing transparency in vessel liability and accountability. Additionally, bolstering universal jurisdiction for addressing core international crimes by lethal systems, will be vital in mitigating the risks of unaccountability and ensuring protection of human rights.

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