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MAV-ISR: from maritime gray zone competition to norm formation

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Maritime Autonomous Vehicles-based Intelligence, Surveillance, and Reconnaissance (MAV-ISR) possesses unique and novel characteristics that distinguish it from other marine activities, providing a stark contrast with the uncertainty of its standing in international law. This ambiguity has resulted in different theoretical interpretations and practical concerns. In the South China Sea, conflicts of interest and practical confrontation between countries within and outside the region have given rise to a competitive gray zone, threatening the stability of the area. To mitigate the potential impact of the MAV-ISR gray zone on the international order, it is necessary to subject it to multidimensional evaluation. Normalizing MAV-ISR is the most thorough method for curbing its gray zone; however, this process should not be rushed. Its advancement should be a gradual process informed by a range of established methods and programs.

KEYWORDS

MAV, ISR, gray zone, South China Sea, normalization

1 Introduction

Due to the advancement of science and technology, the application of maritime autonomous vehicles (MAVs) in intelligence, surveillance and reconnaissance (ISR) holds unique value, and the impacts of such vehicles are deserving of serious consideration. The deployment of ISR tasks for MAVs is not a new idea. Relevant prototypes already exist, and IRS tasks have previously been utilized in practical scenarios. In 2024, the Australian government unveiled its first autonomous vehicle capable of performing undersea tasks, the Ghost Shark prototype. Ghost Shark will allow the Navy to engage in stealthy, long-range autonomous undersea warfare by facilitating the completion of persistent ISR and strike tasks (Sutton, 2024). China's HSU-001, Israel's Blue Whale, France's XLUUV, and Russia's Klavesin-2P-PM MAVs are also considered to have specialized or effective ISR performance (Australian Government Department of Defence, 2024). Compared with maritime activities using ships as the medium, MAV-ISR is somewhat novel. Existing international law has failed to prepare for this scenario; as such, views and practices differ between countries. The actors involved in MAV-ISR are complex and diverse and are not limited to State actors. Non-State actors can manipulate MAV-ISR alone or may work in tandem with State actors via joint ventures, cooperation,

technical support, subscription, donation, etc., introducing several challenges with regard to the identification and allocation of behavioral responsibilities in the existing international law system. Compared to the distinctly sovereign nature of territorial waters and the freedom offered by the high seas, EEZs leave more room for debate with regard to the distribution of maritime rights, making them an excellent testing ground for MAV-ISR. In particular, in areas of geopolitical tension such as the South China Sea, MAV-ISR is likely to be a further source of unpredictability, affecting the regional or even global order. Therefore, this article mainly focuses on MAV-ISR within EEZs, taking the uncertain position of MAV-ISR in international law as a starting point to explore the conflicts between countries with a national interest in MAV-ISR. We argue that this is a gray area that requires balance and mediation to prevent a dangerous situation arising. In 2015, the U.S. Special Operations Command issued a white paper that defined gray zone challenges as competitive interactions among and within State and non-State actors that fall between the traditional war and peace duality (U.S. Special Operations Command, 2015). Gray zones are, by nature, highly uncertain, and these situations are difficult to predict, potentially resulting in international conflict; such concerns cannot be ignored. This article holds that the international community should establish a multidimensional evaluation mechanism for MAV-ISR to determine whether its use is permissible or whether it should be prohibited in certain situations, and to comprehensively evaluate the degree of tension in regional relations, the nature of behavior, the integrity of behavior, the intention and purpose of behavior, and the nature of the actors involved. To resolve the gray zone that arises when MAV-ISR is discussed, it is necessary to normalize it. This normalization process should carefully consider the differences in technology and the strength of MAV-ISR in various countries, as well as the wide range of international legal issues involved, and should follow the principle of ‘gradualism’. Before forming a binding international convention to regulate MAV-ISR, procedural issues and non-binding soft laws with considerable influence should be carefully considered. Moreover, a regional MAV-ISR would be a good ‘test stone’ to assess the applicability and shortcomings of the existing international law system with regard to MAV-ISR, as well as the need and possibility to create new norms at a later date.

2 Method

The article employs a multi-method approach to analyze the legal, geopolitical, and operational challenges posed by MAV-ISR in EEZs, particularly in contested regions like the South China Sea. Below is a breakdown of the key methodological elements:

2.1 Legal and policy analysis

The study employs a critical legal analysis to systematically identify gaps and ambiguities within the existing framework of

international maritime law, particularly the UNCLOS and customary international law, as they pertain to MAV-ISR operations. Special emphasis is placed on unresolved legal questions surrounding permissible activities in EEZs, as well as the evolving challenges posed by mixed actor involvement.

By combining doctrinal legal analysis with empirical operational data, the study both identifies regulatory gaps and examines their security implications, especially in contested regions like the South China Sea. The empirical operational data primarily encompasses three types of data sources. First, the study is based on ISR operational data, primarily citing statistics on maritime reconnaissance activities in the South China Sea from the South China Sea Strategic Situation Probing Initiative (SCSPI). SCSPI is an international research network dedicated to aggregating global intellectual resources and open-source intelligence to provide professional data services and analytical reports. Second, regarding MAV data, the article primarily references information compiled by hisutton.com, a website that collects and analyzes data on various advanced maritime systems, including MAVs. Finally, by reviewing literature on innocent passage, freedom of navigation, the study analyzes different countries’ perspectives on the right of innocent passage for vessels, providing a foundational dataset for the legal analysis of MAV-ISR operations in this research.

2.2 Multidimensional evaluation mechanism

The study develops a multidimensional evaluation framework to systematically assess the permissibility of MAV-ISR operations by examining three critical aspects. First it evaluates strategic risks with particular focus on potential impacts to regional stability and conflict escalation dynamics. Second the framework analyzes operational compliance with established international maritime law and protocols to determine normative adherence. Third it investigates technological disparities among state actors assessing both capability asymmetries and their broader geopolitical implications. This comprehensive approach enables a balanced assessment of MAV-ISR activities within the complex maritime security environment.

2.3 Potential limitations

While this study provides a comprehensive analysis of MAV-ISR operations, several limitations should be acknowledged. First, the reliance on open-source case studies may exclude classified military deployments or cutting-edge technological developments that have not been publicly disclosed. Second, the assessment criteria for determining operational ‘permissibility’ lack universally accepted standards, requiring further refinement through international consensus-building. These constraints may affect the generalizability of the findings but simultaneously highlight critical areas for future research. Addressing these gaps will necessitate enhanced multinational data-sharing mechanisms

and the development of standardized evaluation frameworks to strengthen the robustness of subsequent studies.

3 Results

The uniqueness and novel features of MAV-ISR, including its low political and economic cost, strong concealment, and high efficiency, contribute to its uncertain status in international law. This ambiguity has sparked debates between positive and negative interpretations based on legal regimes and regulations such as freedom of navigation, MSR, due regard and peaceful purposes, stimulating gray zone competition among different countries. The gray zone competition facilitated by MAV-ISR poses a risk to the international order. It is necessary to conduct a multidimensional evaluation of the risk of the gray zone associated with MAV-ISR in combination with regional relations, behavioral integrity, behavioral intention and purpose, and the nature of the subject. This will guide relevant practices towards development in a more rational and consensus-driven direction. Normalization serves as the guarantee to eliminate the risk of the gray zone associated with MAV-ISR. In this process, we should follow the principle of gradualism, consider the rules of transplant and innovation, and steadily advance in accordance with the principles of 'procedural before substantive' and 'regional before international' action.

4 Discussion

4.1 The uniqueness and novelty of MAV-ISR

Neither MAVs nor ISR are precisely defined in international law. Scholarly discussions on MAVs mostly focus on comparing them with ships to determine the legal status of MAVs, and then analyzing their rights and obligations in accordance with international law (McKenzie, 2020). Discussions pertaining to ISR usually have a military focus. This article does not rule out the possibility that MAVs have a ship or ship-like construction, but argues that the MAVs used to engage in ISR are more often non-ship constructions. ISR is predominantly used in military scenarios, but its application extends beyond the military domain, and its economic and political impacts are also worthy of consideration. In general, the term 'MAVs' refers to marine systems that accomplish tasks with little or no human intervention. MAVs are much smaller than conventional submarines, but much larger than swimmer delivery vehicles (SDVs); however, their exact size varies. In recent research, XLUUVs (extra-large uncrewed underwater vehicles) have attracted increased attention. In terms of structure, an MAV is generally composed of a skeleton and a floating body, a propulsion system, a navigation control system and a detection system. Its main body is usually streamlined, and the tail features an integrated structure such as a propeller to support its handling performance. An MAV can be configured with different payloads for different tasks, including execution, attack, transport,

reconnaissance, etc (Miętkiewicz, 2023). They can be remote-controlled or fully autonomous, moving on and off the water, on the surface, and underwater. ISR refers to the collection of data and information that may be considered confidential by the coastal State, for a particular State to use in a manner contrary to the will of the coastal State. MAV-ISR refers to ISR activities using MAVs that are conducted in waters adjacent to coastal States to help specific countries obtain confidential or sensitive marine data and information that will prove advantageous in ongoing or potential political, economic and military conflicts. There are different types of MAVs, including underwater autonomous MAVs (also known as UUVs), which offer greater concealment and avoid the instabilities that arise as a result of remote-controlled signal transmission in underwater environments. They are the preferred type of MAV among ISR practitioners (CENJOWS, 2023). The MAV-ISR discussed in this paper mainly falls within this category. Overall, MAV-ISR possesses the characteristics of low cost, strong concealment, and high efficiency.

Low cost: The low cost of MAV-ISR is reflected in terms of both economic and political costs. Given their structure and body shape, MAVs are relatively agile and lightweight, and far less costly than ordinary ships. They can also be manufactured using techniques such as 3D printing, which is believed to enable rapid customization of the devices at a lower cost (Naval News, 2024). In addition, MAV-ISR requires little consideration of human casualties during its mission. In the event of a dispute over a violation of international law, a coastal State requesting accountability from the State controlling the MAV would need to first prove that the violation could be attributed to a specific State, and the autonomous nature of the MAV may pose an obstacle in this process. In practice, there is no single type of MAV-ISR operator. Operators may be State actors or non-State actors, or even a combination of the two in the form of a joint venture, cooperation, technical support, subscription, donation, etc. Ghost Shark, for example, was developed by Australia's Defense department in a joint venture with the US company Anduril Australia. Ten Australian companies were involved in the research and development, and forty-two Australian companies will benefit from the supply chain (Australian Government Department of Defence, 2024). Norway's Hugin Endurance and South Korea's ASWUUV (anti-submarine uncrewed underwater vehicle) were developed by private companies or groups. This complex and diverse set of actors creates many difficulties in attributing MAV-ISR behavior, which is likely to be abused by relevant actors for their own gain. In other words, when MAV-ISR operators are not purely State actors, the political costs are relatively low. In some tense waters, the advantage provided by MAV-ISR is even more prominent, resulting in greater potential for abuse.

Strong concealment: The MAV is lightweight, with a low sound and electromagnetic response (Schmitt and Goddard, 2016), and is difficult to detect. MAVs deployed underwater can also take advantage of natural concealment resulting from low visibility in the underwater environment. There are many types of MAVs, and even if they have specific markings, it will be difficult for coastal States to effectively identify them whilst they are submerged.

Moreover, MAVs can easily be converted into weapons systems and can even fire torpedoes equipped with nuclear warheads, as exemplified by Russia's nuclear-powered UUV Poseidon. The hidden location and adaptable performance of MAV make them a greater deterrent for coastal States and increase the fear of MAV-ISR in coastal countries.

High efficiency: Their autonomy and high endurance make MAVs highly adaptable to the marine environment, and they can be deployed in extremely harsh conditions. As a result, the coverage of MAV-ISR's activities can be wide-ranging. MAVs can act alone or in formation to complete collective missions. Similarly to biological group behavior, the development and application of swarming technology can help MAVs establish distributed systems and coordinate actions between similar devices (Sahoo et al., 2024). When MAVs, swarming technology and big data are combined, MAV-ISR will have an unprecedented impact in terms of data and information. Effective ISR requires highly accurate and timely information. In the past, marine ISR activities were limited by the breadth of information collection and the speed of information processing, given that marine data are highly transformable and multi-layered. However, coupled with swarming technology and big data, MAV-ISR will be 'data-driven', enabling it to not only collect intelligence directly, in a comprehensive and timely manner, but also discover more potential intelligence through data-mining technology.

It is evident that the above-described characteristics of MAV-ISR are based on technological empowerment and are closely related to innovation and development in the digital era. ISR is a well-established maritime activity, but when MAV-ISR moves from the technical level to the level of international law, it is necessary to interpret the impact that the above characteristics of MAV-ISR may have on the international community from a legal perspective (Khaskheli et al., 2023).

4.2 The legality debate of MAV-ISR

The debate over the legality of MAV-ISR is based on both MAVs and ISR, mainly because the *United Nations Convention on the Law of the Sea* (UNCLOS) lacks explicit guidelines for both, leaving room for different views and interpretations by different countries. This section combines the existing views and possible perspectives of scholars to divide the legitimacy debate of MAV-ISR into positive and negative interpretation theory based on two corresponding aspects. The positive interpretation is based on UNCLOS provisions to provide a positive assessment of MAV-ISR, which is consistent with international law, and states that coastal States should not interfere with such activities. Negative interpretation takes a negative view of the legality of MAV-ISR, positing that such activities pose a threat to coastal States and violate the provisions of international laws such as UNCLOS, and that coastal States are therefore entitled to intervene to deter and stop the use of MAV-ISR. Both positive and negative interpretation theory revolve around specific regimes such as freedom of navigation, marine scientific research (MSR), and immunity in

UNCLOS, as well as abstract norms such as 'peaceful purposes', 'due regard', 'residual rights', and 'permissibility if not prohibited by law'.

4.2.1 Freedom of navigation and 'permissibility if not prohibited by law'

Freedom of navigation related to the right to navigate of non-coastal States. Article 19 of UNCLOS states that ships of a non-coastal State enjoy the right of innocent passage in the territorial sea of a coastal State, but this does not include the gathering of information which damages the defense or security of the coastal State. Article 20 stipulates that submarines or other underwater vehicles must sail over the sea and display their flag in territorial waters. Positive interpreters argue that the right of innocent passage is not limited to ships and can also be enjoyed by MAVs (Daum, 2018). Although Article 19 excludes intelligence-gathering from acts of innocent passage, it is not intelligence-gathering in any sense but emphasizes that it is intended to undermine the defense or security of the coastal State. Both ships and MAVs require certain data receipts in order to achieve normal, safe navigation, even if they may be used for military purposes (Kaye, 2005). Thus, positive interpreters argue that a non-coastal State's MAV-ISR does not violate the innocent passage requirement unless the coastal State can demonstrate that intelligence gathering is detrimental to its national defense or security (Ballester, 2014). Negative interpreters hold that the main purpose of innocent passage is 'passage', and any act unrelated to normal passage violates this aspect of UNCLOS. In the event of uncertainty as to whether the incidental act in question is necessary for normal passage, the coastal State shall have the right to take the necessary steps to confirm it. The essential purpose of MAV-ISR is to obtain information that can be used against coastal States, which is difficult for negative interpreters to accept as a form of legitimate and innocent passage. Coastal states therefore have the right to self-defense or to engage in preventive measures for their own security (Shearer, 2003).

Under UNCLOS, non-coastal States have greater navigational rights than innocent passage rights in archipelagic sea lanes and straits used for international navigation. From the perspective of positive interpretation, the right of innocent passage in the territorial sea does not exclude all types of MAV-ISR, and MAV-ISR should also be permitted in archipelagic sea lanes and international straits. Negative interpreters hold that if the MAV is released by a vessel, whether in archipelagic seaways or in straits used for international navigation, when the ship stops to release the MAV or recovers the MAV, it will violate the requirement that passage must be 'continuous and expeditious' (Henderson, 2006), meaning that the use of MAV-ISR should not be permitted in these two areas.

In accordance with the principle of international law that, if it is not prohibited, it is permissible, the positive interpretation theory holds that UNCLOS only regulates and restricts the gathering of information in Article 19, and that there is no similar provision in the EEZ; thus, MAV-ISR deployed by non-coastal States in the EEZ is not restricted (Pedrozo, 2010). MAV-ISR falls within the category of freedom of navigation and 'other internationally lawful uses of

the seas' (Franckx, 2011), which, in accordance with UNCLOS, is defined by analogy with the relevant content of freedom of the high seas and cannot be arbitrarily restricted by coastal States (Kraska, 2022). A coastal State's ban on MAV-ISR in their EEZ is an excessive maritime claim. Moreover, ISR in foreign EEZs has long been commonplace in terms of state practice, and such activities have been carried out by the United States, Russia and the European Union (Pedrozo, 2010). In response, the negative interpretation theory countered the notion of 'permissibility if not prohibited by law' mentioned in the Lotus case; the Permanent Court of International Justice emphasized the application of the principle within a State; i.e., the jurisdiction of a State within its territory does not depend on the permissible provisions of international law, but when this principle is applied to the rules of demarcation and external rules, it can only serve as a basis for a State to formulate relevant claims, and does not necessarily prove its legitimacy in international law (Chen, 2011). In addition, the vote on the Lotus case was passed by a very narrow majority of votes, and the content of the judgment itself leaves a great deal of room for debate. Moreover, restrictions on MAV-ISR do not equate to restrictions on freedom of navigation, and coastal States oppose only MAV-ISR which threatens their security. According to UNCLOS Article 58, the phrase 'other internationally lawful uses of the sea' emphasizes that these uses must be 'related to these freedoms', which refer to freedom of navigation and overflight and freedom to lay submarine cables and pipelines. The use of MAV-ISR can hardly be interpreted to fall under other internationally lawful uses of the seas in relation to these freedoms (Yu and Zhou, 2021). Finally, many countries oppose ISR activities in the EEZ, such as Bangladesh, Brazil, Cambodia, Myanmar, Iran, Malaysia, etc., and ISR often leads to concurrent anti-ISR State practices (Guo and Zou, 2017); therefore, MAV-ISR lacks sufficient basis in customary international law.

4.2.2 MSR and 'peaceful purposes'

MAV-ISR, which involves the collection of marine data and information, gives rise to positive and negative interpretive debates regarding whether it is a form of MSR, as this affects whether non-coastal States are obliged to obtain the consent of coastal States prior to its deployment.

Positive interpretation theory holds that marine data collection is a superior concept, which includes other marine data collection methods such as military surveys and hydrographic surveys in addition to MSR, and the main difference between them is the purpose of data collection (Pedrozo, 2010). Although UNCLOS does not clearly define these concepts, the coastal State consent regime for MSR does not apply to marine data collection activities other than MSR, and non-coastal States do not need the consent of the coastal State to engage in military surveying, ISR and other activities in EEZs (Pedrozo, 2010). Moreover, the specificity of MAVs determines that the MSR regime does not apply to MAV-ISR. MAVs have certain autonomous navigation capabilities, and their release points are not necessarily located in a country's EEZ, but can be on the high seas, and they may enter the EEZ according to their internal navigation settings. This process is often time-consuming and prone to uncertainty, as the navigation ability of

MAVs may be affected by external factors (Bork et al., 2008). However, UNCLOS Article 248 posits that a non-coastal State shall, at least six months prior to the anticipated commencement of an MSR program, submit information pertaining to the geographical location and timing of the program to the coastal State for review and for determination of consent. Obviously, it is difficult for MAV-ISR to meet this condition, and it is impractical to restrict MAV-ISR under the consent system for MSR.

According to the negative interpretation, distinguishing between different marine data collection methods by purpose is too subjective and limiting the scope of application of the MSR regime by purpose alone risks overriding the regime, to the detriment of the right of consent enjoyed by coastal States. Different marine data collection methods feature similar collection techniques, means and data types (Liu, 2021). With regard to MSR, which enhances human knowledge of the marine environment, UNCLOS gives coastal States exclusive jurisdiction, so there is no reason not to impose stricter regulations on military surveys and ISR, which are more likely to deter coastal States and inevitably lead to situations contrary to the purpose of peaceful uses of the oceans (Zhai, 2023). The preamble to UNCLOS and Articles 88, 141, 240, 242, 246 and 301 clearly states that all ocean activities, including MSR, should be performed for peaceful purposes. Military surveying is a measurement activity that serves military competition and strikes. ISR is broader in scope than military surveys, includes intelligence gathering and surveillance, and is also often used for military purposes. From the perspective of negative interpreters, as a type of military activity, MAV-ISR in foreign EEZs threatens the security of the coastal State and can be regarded as an act of war preparation (Guo and Zou, 2017), which should be carried out only with the consent of the coastal State, like MSR. According to UNCLOS Article 258, the MSR regime applies not only to ships but also to 'installations or equipment'. In terms of the construction of MAVs, MAV-ISR can be regarded as scientific research equipment (SRE) rather than ship-based MSR, which in turn needs to comply with the relevant regulations of MSR (Hofmann and Proelss, 2015). Even if, due to the nature of MAVs, the consent regime for MSR encounters obstacles in its application, it can be solved through legal techniques and other means, and does not necessitate a direct denial of the application of this legal regime.

With regard to the 'peaceful purpose' referred to by negative interpretation, positive interpretation argues that peace is not the same as complete demilitarization. UNCLOS' requirement for peaceful purposes derives from Article 2 of the Charter of the United Nations, which excludes only non-peaceful acts of threat or aggression by force. ISR and military activities such as military exercises and weapons training are not prohibited by international law. Many conventions and regional agreements do not include intelligence gathering on the negative list when referring to peace (Kraska, 2022). The threat and invasion of force require a higher threshold of force presence (International Court of Justice (ICJ), 1986). The main purpose of MAV-ISR is to obtain data and information, and in any case, the minimum threshold of armed attack cannot be met, and coastal States have no right to take self-defense countermeasures against MAV-ISR carried out by non-

coastal States (Kraska, 2022). Moreover, MAV-ISR cannot be broadly categorized as a military activity. Even in the case of MAVs deployed and used by the military, the MAV-ISR itself does not convert data collection into a military survey unless such data collection cannot be performed by civilian research institutes, and it can only be used for military purposes (Bork et al., 2008). Moreover, to suggest that UNCLOS refers to peace for the purpose of completely restricting military activities within EEZs would undoubtedly turn UNCLOS into an arms control agreement, which contradicts the purpose of the Convention. EEZs cover approximately 38% of the world's total ocean area, and complete demilitarization is not conducive to the training of naval forces (Carlisle, 2021). In this regard, the negative interpretation theory indicates that MAV-ISR is the product of technological empowerment, the mastery of relevant technologies in various countries is not at the same level, and not all countries are interested in and able to carry out MAV-ISR in EEZs of other countries (Mou, 2013). Compared with traditional ISR, MAV-ISR has shown an exponential increase in effectiveness, and when it is applied between two unequal countries, technological asymmetry will create economic, political and security-related oppression for the less technologically advanced side, destabilizing the peaceful and stable international order that the international community desires.

4.2.3 Residual right and due regard

Article 59 of UNCLOS is widely interpreted as a provision on residual rights in EEZs, and the Convention itself does not stipulate the specific content of residual rights, only emphasizing that conflict resolution should be based on fairness and should consider all circumstances and the interests of all parties. Positive and negative interpretations consider the freedom of non-coastal States to conduct MAV-ISR and the right of coastal States to regulate MAV-ISR, respectively, as a residual right in EEZs. According to the negative interpretation theory, the rights of coastal States in EEZs are constantly evolving, and are not limited to the rights explicitly listed in UNCLOS, and the coastal State has the right to take certain measures against foreign MAV-ISR in its EEZ (Liu and Li, 2020). The positive interpretation theory holds that EEZs have been established only to grant resource rights to the coastal State (Odom, 2010), and that MAV-ISR has no relevance to resource rights but belongs to the freedom of non-coastal States in EEZs, over which the coastal State has no jurisdiction.

Regardless of whether the residual rights asserted by positive interpretation are valid, negative interpretation holds that MAV-ISR in the EEZ of another State violates the obligation of due regard. Article 58, Paragraph 3, of UNCLOS notes that States shall exercise their rights and obligations in EEZs with due regard to the rights and obligations of coastal States. Due regard to the conceptual connotation is not clear, but it is considered to be an obligation of positive conduct. That is, although the substantive content of this obligation is unclear, some positive actions should be taken in terms of procedure, such as negotiation, notification, consultation, etc., regardless of the final outcome of such acts (International Court of Justice (ICJ), 1974; Permanent Court of Arbitration (PCA), 2015). Thus, MAV-ISR performed by a non-coastal State in the EEZ of a

coastal State is unlawful if the non-coastal State fails to comply with its procedural obligations, such as notification. According to the positive interpretation, due regard corresponds to the legitimate rights of the coastal State (Kraska, 2022). It has yet to be determined whether coastal States have the right to regulate MAV-ISR within their EEZ, let alone their obligation to take due regard.

4.2.4 Immunity

The issue of immunity of the MAV-ISR is a further extension of the dispute over its legality. Positive interpretation maintains that MAV-ISR in foreign EEZs is consistent with international law, that the coastal State has no right to interfere, and that even if the coastal State protests, it cannot take any coercive measures against the MAV undergoing ISR on the basis of state immunity (Kraska, 2022). Positive interpreters usually include MAVs as warships or non-commercial ships to grant MAVs national immunity.¹ However, this perspective fails to acknowledge that MAVs do not have the general attributes of ships.² In this regard, the positive interpretation theory maintains that UNCLOS does not have a clear definition of 'ship' or 'vessel' and that States are fully within their rights to bring MAVs directly into the scope of 'ship' and/or 'vessel' through their domestic laws and grant them immunity based on their contributions and services to the State (Kraska et al., 2023). In addition, state immunity is the embodiment of the sovereign equality between States, and that the State is the rights holder. Even if an MAV is not considered to be warship, or even a ship at all, it can enjoy immunity as state property or may continue to work in service of the government (McLaughlin, 2011). The negative interpretation theory questions MAV's immunity. UNCLOS mainly provides for the immunity of warships and non-commercial ships, and the United Nations Convention on Jurisdictional Immunities of States and Their Property has not yet entered into force; moreover, when MAVs do not have the general attributes of ships, existing international conventions cannot provide a clear basis for their immunity and need to be judged by customary international law. The MAV is the product of scientific and technological innovation, and has not accumulated sufficient state practice and general consensus within the existing international law system to inform customary international law rules that can confer immunity (Daum, 2018). State immunity considers both domestic and international laws. At the level of domestic law, a State is free to decide whether to treat an MAV as a ship or warship and grant it immunity. However, in international law, if there is no established international treaty or international customary law, other States are not obliged to recognize the state immunity claimed by the relevant State. This is especially true when there is tension and confrontation between countries. In addition, negative interpretation emphasizes that state immunity refers specifically to immunity from national jurisdiction and does not imply that there is no liability for the violation, nor

1 The most typical example is the 2007 Commander's Handbook on the Law of Naval Operations, which treated unmanned underwater vehicles as other naval vessels and enjoyed immunity.

2 Warships are a subset of ships, and Article 29 of UNCLOS defines warships by four criteria.

does it prohibit coastal States from implementing the necessary measures to deter foreign MAV-ISR in their EEZs (Liu, 2021).

4.3 MAV-ISR's gray zone competition

The arguments about the legitimacy of MAV-ISR informed by positive and negative interpretation theories are grounded in conflicts of interest, making it difficult to give a simple yes or no answer as to whether deploying MAV-ISR in foreign EEZs should be permitted. This theoretical background has given rise to competing national practices. From a constructivist perspective, these competing practices provide an objective foundation for the normative shaping of MAV-ISR (Finnemore and Sikkink, 1998). MAV-ISR has become a gray zone area for countries to assert and defend their interests. The gray zone represents the competitive interaction between State and non-State actors during the ebb and flow of war and peace. A gray zone is typically characterized by fuzziness, gradualness, and asymmetry. Combining the debate between positive and negative interpretation theory on MAV-ISR, we find that it conforms to the aforementioned gray zone characteristics and is in itself a type of gray zone that provides a source of competition in international society.

4.3.1 The fuzziness of MAV-ISR

The nature, subject, intention and consequences of the behavior of MAV-ISR are uncertain. Positive and negative interpretation theories have their own views on this, resulting in fuzziness and uncertainty: the negative interpretation theory accuses MAV-ISR of being outside the jurisdiction of international law, while the positive interpretation theory focuses on 'permissibility if not prohibited by law', asserting that MAV-ISR activity falls within the domain of freedom of the ocean and therefore is not illegal. These two contradicting theories not only debate whether MAV-ISR enjoys immunity, but should also consider how to deal with the public-private cooperative operation of MAV-ISR in real-world scenarios. In terms of behavioral intention, the positive interpretation theory distinguishes MAV-ISR from MAR and downplays its role and influence in military interests, while the negative interpretation holds that MAV-ISR is an inherent threat to coastal States and represents a type of military preparation on the part of non-coastal States, violating the 'peaceful purpose' adjudicated by UNCLOS; as such, it should be applied *mutatis mutandis* to the consent system for MSR. The lack of clarity regarding the nature, subject and intent of the act affects the prediction of its consequences, including the actual impact MAV-ISR may have on the coastal State (which may perceive it as an accidental act, a systematic provocation, a targeted preparation for war or an armed attack), as well as the possible countermeasures implemented by coastal States (acquiescence, protest, simple eviction, coercive measures or an armed counterattack). Even the resulting changes in inter-state relations and the international social order are unclear.

4.3.2 The gradualness of MAV-ISR

The debates between positive and negative interpretation theories regarding MAV-ISR, whether they pertain to specific rules related to freedom of navigation and MSR, or abstract norms such as due regard and peaceful purposes, have a long history, and MAV-ISR is just a recent but significant interlude in the development of these issues. We cannot hope to solve all the theoretical problems mentioned above. In the search for answers, in order to address relevant concerns, positive and negative interpretation theories will integrate MAV-ISR into existing hypotheses based on their own claims. This aligns with liberal institutionalism's core tenet: regimes lower transaction costs in interstate relations (Keohane, 1984). Therefore, MAV-ISR will inevitably develop alongside other marine problems. In other words, the multi-point theory of international law underpins the development of MAV-ISR. Different points will influence the final development of MAV-ISR, but as yet, there is no equal relationship between a single theoretical point and MAV-ISR. Agents with positive and negative interpretations will, respectively, choose a stronghold that is favorable to their own position when attacking the other party, and the loss of one stronghold will not necessarily lead to gains for other strongholds. The same base can be informed by different aspects, which may correspond to different results. Suppose, based on the concept of due regard, that procedural obligation and substantive obligation are different aspects; it is possible to appear in favor of the negative interpretation of procedural obligation and in favor of the positive interpretation of substantive obligation. The final state of affairs of MAV-ISR will depend on a combination of different points and their various aspects—a dynamic process that will form gradually during the mutual struggle between positive and negative interpretative theories.

4.3.3 The asymmetry of MAV-ISR

The factors that play the most essential role in the legitimacy debate of MAV-ISR are the inconsistency and asymmetry of the interests and abilities supported and defended by positive and negative interpretation theories. Capacity is a means of consolidating and expanding interests. Realist theory posits that international politics is predominantly shaped by the decisions and actions of the most powerful states (Mearsheimer, 2001). The technological developments and innovation represented by MAV-ISR are not available in all countries, and asymmetrical technological capabilities will evolve into negative externalities, strengthening the desire to deter MAV-ISR operations. When technological asymmetry escalates to the level of a 'technological divide', MAV-ISR becomes the exclusive prerogative of technologically advanced states, potentially dealing a devastating blow to the international order. Moreover, the lower economic and political cost of MAVs will greatly reduce the psychological burden on technologically advanced countries privileged with this technology. For the operators of MAV-ISR, when it has mastered the overwhelming advantages of technical capabilities, it is natural to view MAV-ISR positively, rationalizing the pertinence and deterrence of MAV-ISR to obtain competitive advantages and

benefits. The asymmetry created by MAV-ISR's technical capabilities and benefits is the key to promoting the progressive development of MAV-ISR's international situation.

4.4 Multidimensional evaluation criteria for MAV-ISR

With its gray zone status, MAV-ISR represents a destabilizing influence on the natural order. When the actor with asymmetric advantages uses MAV-ISR as a profit harvester without any scruples, it may push the international community to the brink of conflict and war. The best way to resolve this is to clarify the status of MAV-ISR in international law, and to limit any potential ambiguities related to its use. Until this is achieved, the international community will continue to engage in competitive MAV-ISR practices in the long-term. To mitigate the threat, the international community should create certain evaluation criteria for MAV-ISR through different analytical strategies, guiding its development in a more rational and consensual direction. In view of the many controversies associated with MAV-ISR, the corresponding evaluation criteria should be multidimensional; that is, the risk of the gray zone embodied in MAV-ISR should be comprehensively evaluated by means of multi-part testing (MPT). MPT of MAV-ISR should consider the tension posed by regional relations, behavioral integrity, purpose and intent and the nature of the subject.

4.4.1 The tension of regional relations

Based on the inequality of regional development, MAV-ISR should be analyzed in the context of specific regional relations. MAVs' low political and economic costs have led to their extensive deployment in disputed waters, and the development of MAV-ISR will, in turn, increase tensions in these areas. It is likely that the greater the tension in regional relations, the higher the risk of a gray zone represented by MAV-ISR being present in this region. The number of subjects, inter-subject dependence and interaction, extraterritorial intervention, and the establishment and perfection of a dispute resolution mechanism are key to measuring the degree of tension in regional relations.

According to *The U.S. Military Presence in the Asia-Pacific 2020*, the Asia-Pacific region exhibits a more pronounced and complex ISR landscape compared to other regions. Within the Asia-Pacific, the South China Sea stands out as a key focal area for U.S. military ISR operations, even more so than other regional waters (NICSS, 2020). There are a large number of countries in this area, which differ greatly in terms of their politics, economy, religion, and culture. Their communication with each other features both a dependent relationship and a competitive relationship. Regarding the relationship with China, on the one hand, based on the organizational linkage of ASEAN+1, the economic and trade volume between the countries surrounding the South China Sea and China has gradually increased, and there is a growing trend of economic cooperation and mutually beneficial agreements. On the other hand, there are still considerable areas of

dispute in the vast South China Sea, and debates over maritime rights between China and other countries—specifically Vietnam, the Philippines, Malaysia, Indonesia and Brunei—are ongoing. Moreover, the countries in the South China Sea have yet to establish a unified and legally binding regional mechanism for dispute resolution. The *Declaration on the Conduct of States in the South China Sea* is only a political document, and the *Code of Conduct in the South China Sea* is being formulated and its nature is yet to be determined. The tensions in the South China Sea and the complexity of the regional situation are evident.

In addition to countries in the South China Sea, countries outside the region, led by the United States, often participate in and intervene in related affairs in the South China Sea. The South China Sea is a frequent source of MAV-ISR disputes. According to the statistics of SCSPI, in 2024 the U.S. military deployed four ocean surveillance ships – USNS Victorious, USNS Effective, USNS Loyal, and USNS Impeccable – as well as three oceanographic survey ships – USNS Bowditch, USNS Henson, and USNS Mary Sears – in the South China Sea. Their cumulative operational duration reached 706 ship-days, marking a significant increase compared to 2023. Throughout the year, reconnaissance vessels were active in the South China Sea for 343 days, with at least one ship conducting operations nearly continuously, leaving almost no gaps in surveillance coverage (SCSPI, 2025). Since 2009, the United States has defined freedom of navigation (FON) as a national interest and has since frequently entered and exited the South China Sea to advocate for and exercise this right. Meanwhile, the United States actively calls on countries around the South China Sea to enhance their maritime domain awareness through MAV technology to enable them to respond to maritime security threats from China (Shelbourne, 2023). In China's view, the United States has established a secure framework for FON in the South China Sea. This so-called securitization refers to linking specific issues with national interests and security, and then in international exchanges, identifying threats, exaggerating threats, and expressing threats in a standardized manner to legitimize the country's diplomatic strategy and international behavior (Zhang and Zhang, 2020). The Bowditch incident is a manifestation of gray zone behavior wrapped up in the safety issues posed by FON. The United States actively addresses the South China Sea issue, either alone or in conjunction with its allies, by presenting FON as a security issue concerning national interests, with the intention of depriving China of its right to maritime development.³ To cope with the series of gray zone strategies of the United States, China is working to implement relevant de-security measures, including enhancing technology and increasing national practices. The SOSUS (a global underwater sound-monitoring system created by the United States) used during the Cold War once represented the strongest underwater ISR capability in the world (Kajiwara, 2024). With the rapid development of underwater monitoring technology in China and the use of MAV systems

³ The spectrum of competitive strategies in the gray zone ranges from low to high, including six categories: narrative war, deprivation of prosperity, civil intervention, active infiltration, coercive signaling, and proxy disruption (Chen, 2019).

(CENJOWS, 2023), China and the United States have entered into a power struggle for MAV-ISR. The sensor network Underwater Great Wall Project proposed by the China State Shipbuilding Corporation is one of China's strategies for resisting the U.S. SOSUS (Tsering, 2016). In the respective national practices of China and the United States, the MAV-ISR in the South China Sea has entered a gray zone competition state. In terms of crisis management, although there are agreements between the two countries such as the Rules of Behavior for Safety of Air and Maritime Encounters, the *Notification of Major Military Activities, On Establishing A Consultation Mechanism to Strengthen Military Maritime Safety*, and the *Code of Unplanned Encounters at Sea*, these documents have encountered obstacles to their implementation and focus on the activities of naval forces, and thus, their guidance and regulatory effectiveness with regard to MAV-ISR is unclear. This lack of necessary conflict communication and resolution mechanisms, like a racing car without a guardrail, may push the competition between China and the United States in the gray zone of MAV-ISR in the South China Sea to the extreme.

In summary, from a moral point of view, the more tension that exists in an area, the greater restraint that should be exercised with respect to MAV-ISR. However, from the perspective of behavioral rationality, MAV-ISR can pre-empt regional tensions. In the face of international reality, rational behavior often overwhelms international morality, driving national behavior towards a dangerous situation involving competition in the gray zone.

4.4.2 The integrity of the behavior

The integrity of conduct mainly refers to reducing misunderstandings between relevant parties through specific actions. The behavioral integrity of MAV-ISR helps control the gray zone risks it poses. As mentioned above, camouflaged MAV-ISR is a source of unease and fear in coastal States. MAVs do not have the same registration system as ships, and they often operate underwater, making them difficult for coastal States to verify or identify. Without advance notice, coastal States will inevitably assume the worst when MAV-ISR is detected in their waters. After all, it is possible to transform MAVs into autonomous weapon systems (AWSs) using existing technology. Therefore, if the MAV itself has a recognizable identifier, and the relevant parties receive advanced notification of its deployment, it will greatly reduce unnecessary suspicion from the coastal State regarding MAV-ISR. However, in addition to explicit provocations, the need for secrecy inherent in activities such as ISR may discourage States from implementing identification markers and providing prior notification.

MAV-ISR is divided into two forms: active and passive. The former means that the sensors on the MAV are dedicated to ISR, and the latter means that the sensors on the MAV have multiple purposes, with ISR representing only one. In active MAV-ISR, the appearance of the MAV can indicate the advancement of ISR, such as military reconnaissance MAVs. Passive MAV-ISR is difficult to judge based on the appearance of the MAV and the presence of the sensors on the device, and it also needs to be combined with the

purposes of the sensors. Compared with the two, active MAV-ISR is more targeted and is a greater deterrent. Some proponents of positive interpretation, often based on such classification criteria, argue that even if international law restricts MAV-ISR, it is not a blanket restriction. Passive MAV-ISR is permitted, and it is unrealistic to restrict it, because sensors are often necessary for safe navigation (Briguglio and Crupi, 2024). In other words, the essential purpose of passive MAV-ISR is not the acquisition of deterrent intelligence. Based on this, disclosing the active and passive nature of MAV-ISR should be conducive to reducing the gray zone risk of MAV-ISR to a certain extent, but this largely depends on the coastal State's trust in the relevant disclosure method.

The integrity of a MAV-ISR can also be inferred based on the distance of its operating waters from the coastal State. Sensors' ability to identify and transmit intelligence is affected by distance, and the more MAV-ISR targets the coastal State, the closer it usually is to the coastal State's adjacent waters, including territorial sea and their EEZ. Unsurprisingly, regardless of the interpretation of innocent passage, MAV-ISR in territorial sea is highly alarming to the coastal State, and the risk of a gray zone will be a major test of inter-state relations. Unlike the territorial sea, the special nature of the EEZ makes it the most notable practice testing ground for MAV-ISR. The operators of MAV-ISR and the coastal States, respectively, seek the theoretical basis to refute each other in the relevant system or regulation of international law, while the practices of conducting MAV-ISR and, alternatively, calling a halt to such operations are also being implemented. Thus, EEZs are the waters in which the danger of the MAV-ISR gray zone most often erupts. Compared with EEZs, MAV-ISR on the high seas may arouse the concern of coastal States, but the probability of a genuine confrontation is low.

4.4.3 The intention and purpose of the behavior

There is a certain overlap between MAV-ISR and marine data collection. It is difficult, but not impossible, to evaluate MAV-ISR by clarifying the initial intention and ultimate behavioral purpose of MAV-ISR. The information obtained via MAV-ISR is intended to help its operators gain advantages in economic, political, military-related, scientific and technological conflicts with coastal States. Different conflicts correspond to different degrees of deterrence of MAV-ISR, as MAV-ISR based on economic, scientific and technological zones is obviously less of a deterrent than MAV-ISR based on military competition. The advantages gained by the operators of MAV-ISR in military competition directly threaten the national security of the coastal States. Moreover, when these military advantages are used in preparation for an imminent war, MAV-ISR may be perceived by the coastal States as a force attack or a threat of force, which in turn causes the coastal States to respond in self-defense. Even if, theoretically, MAV-ISR can be linked to a force or armed attack, positive and negative interpretations differ; however, this is insufficient to impede practice because, since the adoption of the Charter of the United Nations, the exceptions to Article 51 have often swallowed up the prohibitive provisions of

Article 2, Paragraph 4 (Collins, 2020). Thus, distinguishing the intent and purpose of a MAV-ISR can help mitigate the risk of the gray zone. Intention and purpose are subjective; their externalization and expression are very subtle, and confirming them is challenging. Generally speaking, the relevant statements, explanations, and documents provided by MAV-ISR operators before, during and after the event can be regarded as a reflection of the behavioral intention and purpose of the MAV-ISR. The context of international relations in which MAV-ISR is carried out is also important. When relations between the two countries are relatively peaceful, there is more room for the interpretation of MAV-ISR, but when the relationship between the two countries is tense to the point of preparing for war, it is difficult to accept that MAV-ISR is being conducted for non-military purposes. In addition, the function of the MAV system itself can also reflect the intent or purpose of MAV-ISR. The simpler the function of the MAV system, the more controllable the MAV-ISR is. If the MAV is sufficiently autonomous to be freely converted to AWS, then the intention to deploy and operate MAV-ISR can be reasonably suspected to be based on non-peaceful motivations.

4.4.4 The nature of the subject

Depending on the operators of MAV-ISR, its pertinence to coastal States and the desire for deterrence will also differ. The operator in a MAV-ISR may be a State or a non-State actor, with the former posing more of a gray zone risk than the latter. MAV-ISR often embodies a certain degree of civic participation and forms that are eclectic. As mentioned earlier, this can be high-level involvement, i.e., the company has direct and independent control over the MAV-ISR, from the development of the MAV to the implementation of the ISR. The company can also participate in a government's MAV-ISR-related projects through technical support, research and development cooperation, and supplying funds. Alternatively, governments can obtain an MAV from a company through a commercial order to implement ISR. Moreover, MAVs may also be developed through donations that allow countries to carry out ISR. Defining and classifying such civilian participation and assessing its possible impact on the international order is a complex task. Non-State actors are not universally accepted as subjects of international law. However, certain exceptions are made for international criminal law and international human rights law. More often, however, the question is whether and how sovereign States need to be held accountable for the actions of non-State actors. Compared with the purely government-owned and operated MAV-ISR, civil participation presents certain obstacles when it comes to characterizing the nature, intention, purpose and subject identification of MAV-ISR, reducing the sensitivity of MAV-ISR. From the perspective of international responsibility, the state bears the most responsibility, and when MAV-ISR involving the private sector can be attributed to the state and is illegal, the state still bears responsibility. A completely civilian-led and civilian-controlled MAV-ISR would also represent a possible threat to coastal States. In addition to their commercial competitive advantage, MAV-ISR

technologies may also be built as a means to demonstrate patriotism to contribute to the national strategic interests of the non-State actor's state of nationality. The above four evaluation criteria do not provide a clear verdict regarding the competitive activities of MAV-ISR. Instead, they constitute a dynamic set where different criteria are not isolated, and their respective weights depend on the circumstances of the case. From the perspective of peace and development, multidimensional evaluation of the gray zone competition of MAV-ISR is the trial-and-error and accumulation approach required to normalize MAV-ISR.

4.5 Norm formation of MAV-ISR

Building upon Martha Finnemore and Kathryn Sikkink's constructivist framework, norm development progresses through three distinct phases: emergence, cascading adoption, and eventual internalization (Finnemore and Sikkink, 1998). The transformation of MAV-ISR's multidimensional assessments into established norms fundamentally represents a textual codification process of these evaluative outcomes. This process is gradual and will be accompanied by the development of practices and theories. The relevant technologies and practices of MAV-ISR must be further deepened and popularized. Although the use of MAVs in the ocean has attracted attention for many years, the number of countries that possess the technology and capabilities to deploy and operate MAV-ISR is still relatively limited. The United States is at the forefront of such activities, especially from a military perspective. The U.S. Navy's UUV systems include Force Net, Sea Shield, Sea Strike, and Sea Base, which are used for information processing, defense, attack, and backup support, respectively. ISR is one of the main elements of the Force Network (Henderson, 2006). Few countries can match the United States in terms of technological prowess or economic strength. There are well-established asymmetries in the technology and strength of MAV-ISR, which affect the breadth of MAV-ISR practices. If MAV-ISR issues are normalized overnight at this stage, more extreme situations may arise. As mentioned previously, the normalization of MAV-ISR, which is intertwined with commonplace issues such as freedom of navigation and MSR, will inevitably entail the development of established international law systems or provisions. However, alone, it is insufficient to represent the majority of the international community and will essentially evolve into an opportunity for specific countries to assert their privileges. Therefore, the normalization process of MAV-ISR should be gradual. The doctrine of gradualism consists of three fundamental components: (1) advocating for the strategic employment of non-legal documents in MAV-ISR normalization to mitigate the normative impact of unilateral conduct; (2) addressing technological disparities through technology transfer, collaborative mechanisms, and the dissemination of maritime education/training programs; and (3) developing regulatory frameworks that harmonize transplanted and original norms, while adhering to a sequential development model prioritizing

procedural over substantive rules and regional over international initiatives.

The Tallinn Manual and the *Guidelines for Navigation and Overflight in the Exclusive Economic Zone* are non-legally binding texts that refer to activities such as ISR, but the specific provisions differ considerably. *The Tallinn Manual* is an international law manual pertaining to cyber operations and cyber warfare, and was compiled by NATO's Cooperative Cyber Defense Center of Excellence (CCDCE). In rule 47, it posits that other states may conduct cyber operations within the EEZ of a coastal State, subject to due regard and for peaceful purposes. The use of force is clearly non-peaceful. *The Tallinn Manual* expands the interpretation of force to consider that cyberattacks can constitute the use of force based on eight criteria: severity, immediacy, invasiveness, directness, military character, presumptive legality, state involvement, measurability of effects, and the two elements of 'scale' and 'effect'. Cyberattacks exclude cyberespionage, such as intelligence gathering, because such actions are not considered illegal and do not constitute the use of force (Ji, 2016). Therefore, according to *The Tallinn Manual*, ISR in EEZ is a legitimate military activity. The *Guidelines for Navigation and Overflight in the Exclusive Economic Zone* is a document published on behalf of a group of experts including major Asia-Pacific countries. The guidelines outlined in this document define military activities, military surveying and reconnaissance, clarify that intelligence gathering is a military activity, and emphasize that military activities in a country's EEZ should be peaceful, without the use or threat of force, and free from provocative acts, including the gathering of intelligence in support of the use of force. In short, according to the guidelines, provocative military acts such as ISR against a coastal State should not take place within the EEZ of a coastal State. Evidently, the two documents have diametrically opposed attitudes towards ISR. This regulatory inconsistency is an inevitable part of the process of normalizing MAV-ISR, and it is also a meaningful trial-and-error attempt. The theoretical discussions and practical developments derived from these documents lay an important foundation for the normalization of MAV-ISR.

In addressing the technological asymmetry in MAV-ISR, technology transfer, technical cooperation, and maritime education and training are indispensable. With regard to technology transfer and cooperation, Part XIV of UNCLOS requires states parties to establish mechanisms for promoting the transfer of marine technology (Harden-Davies and Snelgrove, 2020). Although the Convention does not directly regulate non-state actors (Polejack, 2023), this does not necessarily preclude addressing the public-private hybrid nature of MAV-ISR. In the transfer of marine technology, private transactions are susceptible to interference by the will of states participating in global ocean governance. Involving stakeholders in specific marine technology transfer agendas can fully leverage the contributions of non-state actors in ensuring equitable participation in marine activities (Harden-Davies et al., 2024). Notably, technology transfer and cooperation are increasingly intertwined with maritime domain awareness (MDA) strategies,⁴ as exemplified by the Indo-Pacific

MDA Partnership involving the U.S., Japan, India, and Australia (Lou and Wang, 2023), which utilizes high-tech sensor networks and battlefield awareness systems to share intelligence within exclusive political alliances (Liu, 2024). While such collaborations are inherently politicized, they undeniably help narrow technical gaps among limited partners. The global shift toward unmanned and intelligent maritime systems has heightened the need for specialized education (Belabyad et al., 2025), as MAV-ISR is a technology- and knowledge-intensive field involving cutting-edge domains like the Internet of Things and human-machine interaction (Gerakoudi et al., 2024), making structured training programs critical for skill acquisition. In this context, IMO, alongside bodies like UNESCO, could spearhead initiatives to disseminate knowledge on emerging maritime technologies and engage in ocean science diplomacy (Polejack, 2021), thereby elevating the technical and cognitive capacities of nations facing technological disadvantages.

The rulemaking content should balance both transplantability and originality. The uniqueness and novelty of MAV-ISR have sparked numerous debates, with many of these debates revolving around 'concept externalization'. This refers to the flexible interpretation of existing legal concepts in response to the emergence of new substances or phenomena. For example, 'ship', 'force' and 'military activities' have been conceptually externalized in theoretical debates to explain the legitimacy of MAV-ISR.⁵ Concept externalization applies existing legal norms and can provide transferrable rules for MAV-ISR. As a theoretical discussion and practical method, the externalization of concepts has its merits. In the long run, however, its boundaries are difficult to grasp, and adjudicating the use of MAV-ISR purely by transplanting rules is considered deceptive. Therefore, the normalization of MAV-ISR should involve the establishment of targeted rules based on necessary legal transplantation. In this regard, relevant practices of IMO can be referenced. IMO is an important international organization in the maritime field and has initiated research on technical and legal issues related to MASS (Maritime Autonomous Surface Ship). From 2017 until the 103rd

4 According to the definition of the IMO, maritime situation awareness refers to the effective understanding of any matters related to the sea area that may affect security, economy or the environment, including all maritime activities, infrastructure, etc (International Maritime Organization (IMO), 2018).

5 For example, can MAV be considered as an unmanned vessel and relevant provisions of international maritime conventions be applied accordingly? In this regard, 2017, CMI sent Questionnaire on Unmanned Ships to its member associations. The questionnaire covered six categories of issues, including the application of unmanned ships under domestic law, the 1982 United Nations Convention on the Law of the Sea (UNCLOS), the 1974 International Convention for the Safety of Life at Sea (SOLAS), the 1972 International Collision Avoidance Rules (COLREGS), the 1978 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), and the liabilities of unmanned ships (Comité Maritime International (CMI), 2018).

IMO Maritime Safety Committee (MSC) meeting in May 2021, IMO conducted regulatory scoping exercises for different levels of autonomous MASS, examining whether IMO's ship safety regulations can be applied, how they should be applied, and whether further revisions are needed before they can be applied to MASS (Chen, 2023). In April 2022, at the 105th MSC meeting, the MSC approved a roadmap for developing the specification of MASS. The roadmap is goal-oriented and divided into two stages. The first stage will last until the second half of 2024, focusing on the development of non-mandatory norms to guide MASS. The second stage will form mandatory norms to regulate MASS based on the experience of the first stage, and is expected to implement these mandatory norms from January 1, 2028 (International Maritime Organization (IMO), 2022).

The rulemaking process should follow the principles of 'procedural before substantive' and 'regional before international' action. The substantive problem is the focus of the theoretical disputes, while the procedural problem is mainly related to the feasibility of technology and cost; resolving the latter can help to determine the solution to the former. On procedural issues, the registration, marking and notification of MAV-ISR can be prioritized. The registration and marking of MAVs affect the identification of their identities, which is the basis for the identification of illegal acts and the allocation of international responsibility and other substantive issues. In the existing provisions of international law, the registration and marking of ships can serve as a kind of comparison. The Society for Underwater Technology (SUT) clarifies the marking requirements for underwater vehicles in *The Operation of Autonomous Underwater Vehicles, Volume One: Recommended Code of Practice for the Operation of Autonomous Marine Vehicles*. The *Draft Convention on the Legal Status of Ocean Data Acquisition Systems, Aids and Devices* (the ODAS Draft) prepared and reviewed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Intergovernmental Maritime Consultative Organization (IMCO) has similar provisions. Given the mobility of MAVs, prior notification of the presence of MAV-ISR may be costly and, to some extent, impractical, but it is not impossible. For example, when an MAV is deployed on the high seas that may enter the EEZs of other States, the owner and operator may notify the 'potentially affected States' accordingly at the time of deployment. For substantive issues, creating a negative list can serve as a preliminary step. Different forms of MAV-ISR exhibit varying degrees of pertinence and deterrence. Those with significant deterrence capabilities may be considered for inclusion in the negative list, thereby restricting their implementation. For example, MAVs that can autonomously convert to AWS and engage in a direct armed attack may be included in the negative list of MAV-ISR technologies until reliable technical controllability is achieved.

The tension in regional relations intersects with MAV-ISR. The most controversial region is also the region where the use of MAV-ISR is the most frequent. The normalization of MAV-ISR in a specific region followed by promotion to the international level can better

ensure the compatibility of MAV-ISR norms and practices. The South China Sea is the current focus of the international community and is the main area in which MAV-ISR disputes occur, involving major powers such as China and the United States. If the normalization of MAV-ISR can be realized in the South China Sea, its normative demonstration power can be imagined. Encouragingly, according to information from the 2023 *ASEAN Maritime Outlook*, the formulation of the *Code of Conduct in the South China Sea* (COC) has made substantive progress. The second reading of the COC text was completed during the 39th Working Group Meeting on the Implementation of the *Declaration on the Conduct of Parties in the South China Sea* (DOC) in May 2023. Furthermore, the *Guidelines for Accelerating the Early Conclusion of an Effective and Substantial Code of Conduct in the South China Sea* was adopted in July of the same year (ASEAN, 2023). This reflects regional cohesion and a collective maritime consciousness (Hassanali, 2022). Building upon ASEAN's existing cooperative frameworks in maritime search and rescue, maritime domain awareness, and maritime law enforcement, the COC is expected to provide groundbreaking guidance for MAV-ISR operations in terms of political mutual trust and rules-based governance.

4.6 Recommendations for addressing the techno-legal challenges of MAV-ISR

Based on the preceding analysis and discussion, this paper proposes the following recommendations for potential policymakers, legal practitioners, and law enforcement officers:

For policymakers, constructing governance mechanisms tailored to the operational characteristics of MAV-ISR is an essential obligation for responsible state actors. This may include:

- (a) Promoting a multilateral registration system for MAVs, drawing on the model of unified vessel registration and the Automatic Identification System (AIS);
- (b) Enhancing the behavioral integrity and information transparency of MAV-ISR operations to prevent political miscalculations that could destabilize the international order;
- (c) Actively participating in the IMO regulatory process to collaboratively define technical standards and liability frameworks for MAV-ISR through multilateral cooperation rather than exclusive 'mini-lateral' alliances.

For legal practitioners, improving existing international legal norms and developing new rules should be prioritized. However, the process should be gradual and mindful of the following:

- (a) Acknowledging the normative influence of non-legal instruments and non-state actors on MAV-ISR governance;
- (b) Guarding against the erosion of normative justice by hegemonic powers leveraging technological superiority;

- (c) Adopting a ‘procedure before substance’ approach in international rulemaking while drawing on mature regional experiences.

For law enforcement officers, establishing a tiered response mechanism for MAV-ISR incidents is critical. This involves:

- (a) Conducting risk assessments and characterizations of MAV-ISR activities based on jurisdictional waters and situational contexts;
- (b) Clarifying corresponding response measures, ranging from diplomatic protests and non-confrontational expulsion to coercive actions and armed countermeasures when necessary;
- (c) Incorporating MAV-ISR into existing bilateral or multilateral maritime crisis management agreements with relevant states and adhering to these protocols during enforcement operations to avoid unnecessary escalation.

Data availability statement

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

Author contributions

LC: Writing – original draft, Writing – review & editing.

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