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«The role of Artificial Intelligence in maritime surveillance and security under the Law of the Sea and International Human Rights Law »

Ioannis Sokos

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Three Member Committee:

Sofia Galani, Assistant Professor at Panteion University (Supervisor)

Maria – Daniella Marouda, Professor at Panteion University

Vassilis Hatzopoulos, Professor at Panteion University and Visiting Professor at College of Europe, Bruges

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List of Abbreviations

AI	Artificial Intelligence
AIS	Automatic Identification System
ADM	Automated Decision Making
CFR	Charter of Fundamental Rights of the European Union
CISE	Common Information Sharing Environment
COLREGs	Convention on the International Regulations for Preventing Collisions at Sea
ECtHR	European Court of Human Rights
ECHR	European Convention on Human Rights
EEZ	Exclusive Economic Zone
EIBM	European Integrated Border Management
EU	European Union
EUROSUR	European Border Surveillance System
FAO	Food and Agriculture Organization
HRC	Human Rights Committee
ICCPR	International Covenant on Civil and Political Rights
ICJ	International Court of Justice
IFC	Information Fusion Centre
IHRL	International Human Rights Law
IMO	International Maritime Organization
IPMDA	Indo-Pacific Partnership for Maritime Domain Awareness
LRIT	Long-Range Identification and Tracking
LOS	Law of the Sea
MASS	Maritime Autonomous Surface Ships
MDA	Maritime Domain Awareness
MIZ	Maritime Identification Zone
MOTR	Maritime Operational Threat Response
NMDAP	National Maritime Domain Awareness Plan
NSMS	National Strategy for Maritime Security
QUAD	Quadrilateral Security Dialogue
ROC	Remote Operations Centre
RSE	Regulatory Scoping Exercise
SAR	Synthetic Aperture Radar
SAR Convention	International Convention on Maritime Search and Rescue
SOLAS	International Convention for the Safety of Life at Sea
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNHCR	United Nations High Commissioner for Refugees
UNODC	United Nations Office on Drugs and Crime

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Abstract

Compared to traditional forms of maritime monitoring, the integration of Artificial Intelligence (AI) into maritime surveillance has significantly enhanced States' ability to monitor activities at sea. While international law governing the maritime domain does not regulate AI as such, the use of AI-based surveillance technologies raises critical questions regarding the application of existing legal frameworks. More specifically, this thesis examines the legal implications of AI-based maritime surveillance under the Law of the Sea and International Human Rights Law. Using a doctrinal and analytical approach, it examines relevant international jurisprudence and institutional practice to determine whether AI alters States' international obligations or the ways in which those obligations are applied in practice. The analysis demonstrates that while AI does not modify the normative content of States' obligations, it does affect how these obligations are triggered at sea. In particular, AI-based surveillance influences how States acquire knowledge, exercise control, and make decisions affecting individuals in maritime contexts. The thesis concludes that the use of AI in maritime surveillance technologies does not fall outside existing international legal frameworks, but rather reveals how legal concepts, developed in an earlier technological context, are required to adapt to a newly emerging operational environment.

***Keywords**:* Artificial Intelligence; Maritime Surveillance; Law of the Sea; International Human Rights Law; Jurisdiction

"If we make the digital future, it will be a human future.

If it is made for us, it will not be ours."

— Shoshana Zuboff, The Age of Surveillance Capitalism

Chapter 1: Introduction

The last decade has seen a rapid growth in the availability of data and data-driven tools aimed at supporting surveillance and security activities at sea. These developments are closely linked to the changing nature of maritime security, in which threats arise from illicit activity, competition over maritime resources, and geopolitical dynamics, all of which place greater demands on States' capacity to surveil vast maritime spaces.[1] In response, States and international organizations have turned to digital and automated technologies, including Artificial Intelligence (hereinafter AI) to enhance maritime surveillance. These AI-based systems enable the assessment of activities across maritime domains that are difficult to govern through traditional means alone.[2]

This recent shift towards AI and data-driven maritime surveillance raises important questions about how such practices can be accommodated within the existing legal framework governing State conduct at sea. In particular, it introduces the central research question of this thesis*: how does the use of Artificial Intelligence in maritime surveillance systems affect the application of the Law of the Sea and International Human Rights Law?* The thesis argues that while the use of AI in maritime surveillance does not change the formal content of States' obligations under either legal framework, it does affect how those obligations are triggered in practice. In the context of the Law of the Sea, AI-based surveillance affects the exercise of jurisdiction and the fulfilment of compliance obligations across maritime spaces, while under international human rights law it alters how and when human rights obligations are engaged at sea.

The thesis is structured as follows. First, the technological and institutional context of contemporary maritime surveillance is established, providing the necessary background for understanding how AI is integrated into the maritime domain. Building on this foundation, the next chapter examines the implications of these developments for the application of the Law of the Sea, with particular attention to how AI-based surveillance influences the practical exercise of jurisdiction. Chapter 4 then turns to international human rights law, analysing how the use of AI in maritime surveillance triggers human rights obligations and which human rights are mostly affected by AI. Then, the last chapter brings these analyses together by examining the points of convergence and divergence between the two legal frameworks and by summarising the main findings of the thesis, reflecting on their significance.

[1] Kashif Talpur and others, 'AI in Maritime Security: Applications, Challenges, Future Directions, and Key Data Sources' (2025) 16 Information 658, 1, https://doi.org/10.3390/info16080658, accessed 15 November 2025

[2] Ziaul Haque Munim and others, 'Big Data and Artificial Intelligence in the Maritime Industry: A Bibliometric Review and Future Research Directions' (2020) 47(5) Maritime Policy & Management 577, 577–579

1.1. Methodology

This thesis adopts a doctrinal and analytical methodology situated within the field of public international law. Its primary objective is to examine how the use of Artificial Intelligence in maritime surveillance affects the application and operation of existing international legal frameworks, rather than to propose new regulatory regimes or technical solutions. The research is therefore interpretive in nature, focusing on how established legal obligations are engaged in technologically mediated contexts.

The core methodological approach consists of doctrinal interpretation of international legal sources, with particular emphasis on the United Nations Convention on the Law of the Sea and key instruments of International Human Rights Law, including the ICCPR, the ECHR and the Refugee Convention. These instruments are analysed through established legal concepts such as jurisdiction, sovereignty, effective control, due diligence and State responsibility, in order to assess whether and how AI-based maritime surveillance practices interact with States' existing obligations.

The thesis further relies on jurisprudential analysis of relevant international case law, notably from the International Court of Justice, the European Court of Human Rights and the UN Human Rights Committee. Judicial and quasi-judicial decisions are used to clarify the scope of extraterritorial obligations at sea and to assess how technologically mediated forms of control may trigger legal responsibility under both the Law of the Sea and International Human Rights Law. In addition, the research draws on institutional practice and selected soft-law instruments, including processes and guidelines developed within the framework of the International Maritime Organization, as well as regional maritime surveillance mechanisms and relevant practice of EU bodies and UN agencies. These materials are not treated as binding law but are used to contextualise the application of treaty obligations and to illustrate how maritime security governance operates in practice alongside formal legal norms.

Engagement with AI is limited and functional, serving only to the extent necessary to assess its legal implications. The thesis does not employ empirical, quantitative or technical methodologies, nor does it evaluate the performance of specific AI systems. Instead, technological developments are examined from a legal and governance perspective, insofar as they affect jurisdiction, accountability and the protection of individual rights at sea.

In conclusion, the scope of the thesis is limited to the use of AI by States and international or regional actors in maritime surveillance and border-management contexts. The analysis focuses exclusively on the Law of the Sea and International Human Rights Law, and does not extend to international humanitarian law, domestic legal regimes, or detailed policy reform proposals. These limitations are adopted in order to preserve doctrinal coherence and analytical depth.

Chapter 2: Artificial Intelligence and Maritime Surveillance: Concepts and Context

Artificial Intelligence has become a defining feature of twenty-first-century security governance by automating processes that were once in the exclusive domain of human operators.[3] Within the maritime domain, AI is reshaping how States and international organisations monitor and control movement across borders. More specifically, it supports large-scale data integration, by combining satellite imagery, vessel-tracking data, and sensor networks in order to generate situational awareness across expansive ocean spaces.[4] Through data-driven and algorithmic tools, AI allows authorities to identify, classify, and predict maritime activities in real time —capabilities that are now indispensable for the detection of irregular migration routes, smuggling patterns, and search-and-rescue coordination.[5] This combination of information from satellites, coastal radars, drones, and vessel-tracking systems produces a continuous operational picture that can support risk analysis and enforcement decisions in the field of maritime surveillance. While such tools promise greater efficiency and precision, they also raise complex questions about accountability, transparency, and the human oversight of automated processes—questions that have direct legal implications under both the Law of the Sea and International Human Rights Law.[6]

The aim of this chapter is therefore to examine how AI technologies function within maritime surveillance systems and to clarify the institutional setting in which they operate. By analysing the main technologies that are being used in AI-based maritime surveillance, this chapter lays the foundation for the subsequent discussion on their legal and human-rights implications, which will be examined in the following chapters.

2.1. Artificial Intelligence and Automated Surveillance

AI technology is deployed across public and private domains all around the world to perform functions traditionally associated with human cognition—such as learning from data, recognising images and speech, and processing natural language.[7] Even though the concept

[3] Alberto Rinaldi and Sue Anne Teo, 'The Use of Artificial Intelligence Technologies in Border and Migration Control and the Subtle Erosion of Human Rights' (2025) 74 ICLQ, 61–62

[4] Matthew J McCarthy et al., 'Satellite Remote Sensing for Coastal Management: A Review of Successful Applications' (2017) 60 Environmental Management 13, p. 14; Alberto Rinaldi and Sue Anne Teo, 'The Use of Artificial Intelligence Technologies in Border and Migration Control and the Subtle Erosion of Human Rights' (2025) 74 International and Comparative Law Quarterly, 62

[5] Alberto Rinaldi and Sue Anne Teo (n. 3), 62-63.

[6] Giulia Raimondo, 'The European Integrated Border Management: Frontex, Human Rights, and International Responsibility' (Cambridge University Press 2023) Ch. 3.

[7] Ana Beduschi, 'International Migration Management in the Age of Artificial Intelligence' (2021) 9 Migration Studies 576, 1.

of AI is not new, there is no single universally accepted legal definition, as different institutions and jurisdictions define AI according to their policy needs.[8]

However, UNESCO's 2021 *Recommendation on the Ethics of Artificial Intelligence*, adopted by 193 Member States, constitutes one of the most widely endorsed normative frameworks on AI, while refraining from providing a single definition, "since such a definition would need to change over time, in accordance with technological developments".[9] Additionally, the definition of the US National Artificial Intelligence Initiative Act of 2020 should be taken into consideration, defining AI as "a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. Artificial intelligence systems use machine and human-based inputs to- (A) perceive real and virtual environments; (B) abstract such perceptions into models through analysis in an automated manner; and (C) use model inference to formulate options for information or action." [10]

In much of the relevant literature, AI systems are commonly discussed in functional terms, distinguishing between data-driven analytics, machine-learning techniques, and automated decision-making processes. Machine learning enables computers to identify patterns and improve performance from experience without explicit programming, while data analytics allows for the processing and interpretation of vast, complex information to produce meaningful insights. [11] The interaction between learning algorithms, analytical modelling, and automation forms the "core operational triad" of modern AI systems, allowing for predictive and adaptive behaviour.[12] Within governance and security frameworks, such technologies emphasize on decision-support systems and surveillance infrastructures, marking a broader shift toward data-driven governance and predictive control. [13]

The growing impact of AI and its integration into data-driven governance inevitably extends to the maritime and border-management field. As governments and international organizations seek to enhance monitoring over ocean spaces, AI's analytical and predictive capacities offer a great potential for surveillance and operational efficiency. This expansion also introduces new layers of complexity, as decision-making processes once reliant only on human judgment become now embedded within algorithmic systems. Therefore, the following section examines how these AI technological principles are applied in practice to the surveillance of the maritime domain.

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[8] Mark Coeckelbergh, 'AI Ethics' (MIT Press 2020) ch 1–2.

[9] UNESCO, Recommendation on the Ethics of Artificial Intelligence (adopted 24 November 2021), 10 https://unesdoc.unesco.org/ark:/48223/pf0000381137, accessed 4 November 2025.

[10] National Artificial Intelligence Initiative Act 2020, § 5002(3), codified at 15 USC § 9401(3), in National Defense Authorization Act for Fiscal Year 2021 (Public Law 116-283, 1 January 2021).

[11] N Mukhamediev et al., 'Review of Artificial Intelligence and Machine Learning' (2022) 10 Mathematics 2552, https://www.mdpi.com/2227-7390/10/15/2552, accessed 17 October 2025.

[12] I H Sarker, 'AI-Based Modeling: Techniques, Applications and Research Issues Towards Automation, Intelligent and Smart Systems' (2022) SN Computer Science 3:158, https://link.springer.com/article/10.1007/s42979-022-01043-x, accessed 17 October 2025.

[13] Alberto Rinaldi and Sue Anne Teo, 'The Use of Artificial Intelligence Technologies in Border and Migration Control and the Subtle Erosion of Human Rights' (2025) 74 International and Comparative Law Quarterly, 62.

2.2. AI in the Maritime Domain

The use of technology to monitor and manage maritime spaces predates the recent emergence of Artificial Intelligence. States have long recognised the need, for what became known as Maritime Domain Awareness (hereinafter MDA), in order to protect their maritime borders and therefore, facilitate the sharing of information transnationally between intelligence and law enforcement agencies. MDA has been defined by the International Maritime Organization (IMO) as: "the effective understanding of any activity associated with the maritime environment that could impact upon security, safety, economy or the environment." [14]

The United States first adopted the term in 2005 within the framework of the broader "U.S. National Strategy for Maritime Security (NSMS)."[15] More specifically, parts of the NSMS were the "U.S. National Plan to achieve Maritime Domain Awareness" and the "Maritime Operational Threat Response Plan (MOTR)", which was complementary to the MDA Strategy.[16] Both of them were issued in order to better coordinate the interagency response to certain maritime security threats, including "drug/migrant interdiction, fisheries violations, bomb threats, radiation/nuclear alarm resolution and piracy."[17] Following the example set by the US in 2005, MDA has developed into a universal framework for maritime governance, with national and international variations implemented across all major oceanic regions, such as Southeast Asia, Western Indian Ocean, Indian Ocean, South Pacific and North Atlantic. The only maritime region without a dedicated MDA coverage remains the South Atlantic.[18]

All early MDA initiatives depended heavily on traditional surveillance methods such as, in-person observation, coastal radars, patrol vessels and aerial reconnaissance, which suffer from high costs, limited coverage and delayed response.[19] In addition, the quantity of maritime data produced by AIS (Automatic Identification Systems),[20] SAR (Synthetic Aperture

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[14] International Maritime Organization, MSC.1/Circ. 1415, 'Amendments to the International Aeronautical and Maritime Search and Rescue (IAMSAR)' Manual 11 (May 25, 2012), 11, http://www.mardep.gov.hk/en/msnote/pdf/msin1242anx1.pdf, accessed 18 October 2025

[15] US Department of Homeland Security, 'National Strategy for Maritime Security' (September 2005), https://www.dhs.gov/national-plan-achieve-maritime-domain-awareness, accessed 19 October 2025.

[16] US Department of Homeland Security, 'National Plan to Achieve Maritime Domain Awareness' (October 2005), https://www.dhs.gov/sites/default/files/publications/HSPD_MDAPlan_0.pdf,; 'Maritime Operational Threat Response Plan' (October 2005), https://nmio.ise.gov/Activities/Maritime-Operational-Threat-Response/, accessed 4 November 2025.

[17] Gary L. Tomasulo Jr., 'Evolution of Interagency Cooperation in the United States Government: The Maritime Operational Threat Response Plan 3' (June 2010) (unpublished M.B.A. thesis, Alfred P. Sloan School of Management, Massachusetts Institute of Technology), https://dspace.mit.edu/bitstream/handle/1721.1/59157/659552377-MIT.pdf?sequence=2, accessed 4 November 2025

[18] Christian Bueger, Timothy Edmunds and Jan Stockbruegger, 'UNCLOS under Fire: Recalibrating Maritime Security Governance' (2025) 74(Supp) ICLQ 85, 97.

[19] Kashif Talpur and others, 'AI in Maritime Security: Applications, Challenges, Future Directions, and Key Data Sources' (2025) 16 Information 658, 1.

[20] International Maritime Organization, Automatic Identification Systems (AIS) Transponders (IMO, 2025) https://www.imo.org/en/OurWork/Safety/Pages/AIS.aspx, accessed 18 October 2025:

Radar),[21] and drone surveillance systems is too extensive to be processed manually in a timely and consistent manner.[22] However, the recent developments concerning AI and deep learning techniques came to help to overcome these limitations.

The introduction of AI and, more specifically, machine- and deep-learning techniques have enabled, among other things, the ability to process vast multimodal datasets from satellites, AIS, SAR, unmanned aerial and surface vehicles, and coastal sensors to detect, classify, and predict vessel behaviour in real time.[23] While AIS provides near real time vessel-to-vessel and coastal communication, Long Range Identification and Tracking system (LRIT) complements it by transmitting encrypted position reports over satellite links to designated data centres, allowing authorities to track vessels beyond coastal radar range and across oceanic regions.[24] The LRIT system was one of the first MDA tools put in force in 2009 as Regulation 19-1 of the International Convention for the Safety of Life at Sea (hereinafter SOLAS).[25] However, a major limitation of LRIT is, that it is of no use in relation to the frequent use of small boats for drug and immigrant smuggling since it applies only to passenger and cargo ships of at least 300 gross tons and mobile offshore drilling units.[26]

This is where the more recent deep-learning models can be of great use. Convolutional and recurrent neural networks (CNNs and RNNs), transformers, and multimodal fusion architectures enable automated object detection, anomaly identification, and situational awareness with accuracy far beyond traditional means.[27] These techniques, in order to overcome certain difficulties, such as different weather conditions, integrate complementary data sources—satellite imagery, radar, AIS, and electro-optical or infrared video—to generate a unified maritime picture, a process often referred to as *multimodal data fusion*.[28] When combined with vessel-tracking data from the AIS and drone-based reconnaissance, these technologies form the core of automated detection infrastructures. They identify

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'Automatic Identification Systems (AIS) transponders are designed to be capable of providing position, identification and other information about the ship to other ships and to coastal authorities automatically'.

[21] International Maritime Organization, Amendments to the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, Volume II (MSC.1/Circ.1415, 25 May 2012) 11 http://www.mardep.gov.hk/en/msnote/pdf/msin1242anx1.pdf, accessed 18 October 2025:
'Synthetic Aperture Radar (SAR) is a radar system that uses the motion of the radar antenna over a target region to provide finer spatial resolution than conventional beam-scanning radars; it is capable of detecting vessels and other objects at sea under all weather and lighting conditions.'

[22] C Gamage, R Dinalankara, J Samarabandu and A Subasinghe, 'A Comprehensive Survey on the Applications of Machine Learning Techniques on Maritime Surveillance to Detect Abnormal Maritime Vessel Behaviours' (2023) 22 WMU Journal of Maritime Affairs, 447–477, https://link.springer.com/article/10.1007/s13437-023-00312-7, accessed 4 November 2025.

[23] Kashif Talpur and others, 'AI in Maritime Security: Applications, Challenges, Future Directions, and Key Data Sources' (2025) 16 Information 658, 3-4

[24] International Maritime Organization, Long-Range Identification and Tracking (LRIT) System (IMO, 2025) https://www.imo.org/en/OurWork/Safety/Pages/LRIT.aspx, accessed 5 November 2025:

[25] International Convention for the Safety of Life at Sea, Ch. 5, reg. 19-1, ¶ 5.3, Nov. 1, 1974, 1184 U.N.T.S. 278 (2007 revision)

[26] Douglas Guilfoyle, 'Maritime Law Enforcement Operations and Intelligence in an Age of Maritime Security' (2017) 93 International Law Studies 298, 306–307.

[27] Kashif Talpur and others (n 23), 2-3.

[28] Ibid. 13.

irregularities such as AIS silence, erratic vessel trajectories, or movements consistent with smuggling and unauthorized crossings. [29]

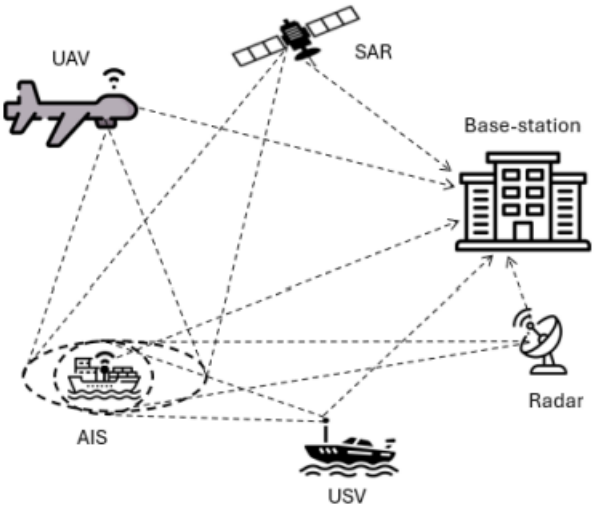

Figure 1. *Multimodal data fusion.*
Source*: Talpur et al., AI in Maritime Security: Applications, Challenges, Future Directions, and Key Data Sources (2025)*

In practice, these developments have enhanced States' ability to identify a range of maritime threats, including irregular migration, drug trafficking, illegal fishing, and environmental violations. For example, deep-learning detectors like "YOLO" and "RetinaNet" have been used to locate unregistered or so-called "dark" vessels by correlating SAR imagery with missing AIS signals.[30]

2.3. Institutional and Governance Dimensions of AI in Maritime Border Management

The growing reliance on digital surveillance technologies has reshaped how States and international organisations govern the oceans. This transformation has produced diverse institutional and governance frameworks that determine how AI is deployed, coordinated, and supervised at sea. Across regions, maritime security governance has evolved toward risk-based and data-driven models designed to enhance situational awareness through the fusion of all the aforementioned technologies.

Despite jurisdictional or policy-based variations, these frameworks share the common objective to improve maritime security through the timely collection, analysis, and exchange

[29] Jorge P Rodríguez et al., 'Identification of Suspicious Behaviour through Anomalies in the Tracking Data of Fishing Vessels' (2024) 13 EPJ Data Science 23, 1
[30] A Rinaldi and S A Teo, 'The Use of Artificial Intelligence Technologies in Border and Migration Control and the Subtle Erosion of Human Rights' (2025) 74 ICLQ 61, 63–64.

of information. Each system seeks to extend States' capacity to monitor their maritime domains and respond rapidly to incidents at sea. However, the ability to pursue these objectives is unevenly distributed and differently regulated. As a result, the global shift toward technologically enabled border management reveals not only contrasting governance philosophies, when it comes to the use of AI, but also structural disparities in capability. This section therefore examines both the technical characteristics of AI that influence the governance of maritime surveillance and the institutional responses that have emerged across regions to manage these developments.

2.3.1. How technical AI features can shape maritime governance?

The design and functioning of AI-based surveillance systems shape how authorities perceive and exercise control at sea, influencing both the scope of surveillance and the nature of decision-making. As States and regional organisations integrate automated tools into their border-management systems, the technological architecture itself begins to determine what kinds of rules, oversight, and accountability mechanisms are required. In other words, technology can produce new forms of governance by defining anew what is visible or actionable at sea.

Firstly, predictive analytics allow authorities not only to detect but also to anticipate any vessel movements and potential irregular activities, shifting in that way border management from reactive monitoring to preventive control.[31] Secondly, AI, as mentioned in the previous section, depends on the interoperability and fusion of heterogeneous data sources—satellites, radar, drones, and identification systems such as AIS and LRIT—requiring extensive information-sharing between agencies and States. This raises legal and governance challenges related to data protection and cross-border accountability. Thirdly, many of these systems operate as "black boxes" whose decision-making logic is difficult to assess, complicating transparency and liability when it comes to unlawful discrimination.[32] Lastly, because much of the technology is developed by private defence and analytics companies, public authorities often depend on contractual rather than legal safeguards to ensure compliance with human-rights or data-protection standards.[33] These emerging technical realities account for why certain jurisdictions, most notably the European Union, have embedded legal controls on automation within their institutional design, and why AI simultaneously poses significant threats to specific human rights, as discussed later in the thesis.

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[31] Kashif Talpur and others, 'AI in Maritime Security: Applications, Challenges, Future Directions, and Key Data Sources' (2025) 16 Information 658, 5-6.
[32] Ana Beduschi, 'International Migration Management in the Age of Artificial Intelligence' (2020) 9 Migration Studies 576, 7.
[33] Giulia Raimondo, 'The European Integrated Border Management: Frontex, Human Rights, and International Responsibility' (Cambridge University Press 2023) ch 3, 109-112.

2.3.2. The Emerging "Two-Speed" System

While a limited number of actors, such as the European Union (hereinafter EU) and a handful of technologically capable States, possess the infrastructure and expertise to use properly AI-based monitoring systems, many others remain reliant on external partnerships or private technologies.[34] This dynamic contributes to what Norris has described as the emergence of the so-called "digital divide",[35] where "AI-capable" States, as Beduschi describes them,[36] shape standards and practices, that less technologically advanced States must follow without meaningful participation or oversight. The global distribution of AI in surveillance mechanisms may cause asymmetries of power, as technologically dominant actors consolidate their influence through control over data infrastructures and algorithmic decision-making.[37] Similar dynamics are visible within the maritime domain, where access to advanced systems, such as EUROSUR and other satellite-based surveillance platforms, determines a State's capacity to detect irregular maritime movements. [38]

The implications extend beyond operational inequality. As aforementioned, in order to achieve effective maritime law enforcement, it is necessary to have a decent degree of MDA, that many States cannot independently achieve.[39] Therefore, they are forced to rely on data-sharing arrangements that raise even more complex issues of accountability. This dependence structure reflects a deeper imbalance in the global governance of technology, where access to information becomes a key factor shaping a State's ability to exercise its rights and obligations under the Law of the Sea. There is a high risk here, of establishing a hierarchy of "AI-capable" and "AI-dependent" States,[40] leading to a fragmentation of international cooperation. However, even for the AI-capable states, the increasing autonomy of AI-systems raises totally new challenges concerning human oversight, accountability and the preservation of lawful control over maritime operations.

2.3.3. Divergent Regional Approaches

Although all States, both "AI-dependent" and "AI-capable" share the same goal, i.e. to achieve better maritime security globally, the ways in which they integrate the AI-tools show significant differences. The governance of AI-based border security is developing across two broad trajectories. The first, exemplified by the EU, follows a normative, rights-based

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[34] Ana Beduschi, 'International Migration Management in the Age of Artificial Intelligence' (2020) 9 Migration Studies 576, 4.
[35] Pippa Norris, Digital Divide: Civic Engagement, Information Poverty and the Internet Worldwide (Cambridge University Press 2001).
[36] Beduschi, (n 34), 4.
[37] Ibid. 4-5
[38] Giulia Raimondo, The European Integrated Border Management: Frontex, Human Rights, and International Responsibility (Hart 2024), 22–25.
[39] Douglas Guilfoyle, 'Maritime Law Enforcement Operations and Intelligence in an Age of Maritime Security' (2017) 93 International Law Studies 298, p. 301–305.
[40] Beduschi (n 36), 6.

framework, while the second, mostly dominant across North America and Asia-Pacific, treats AI primarily as an operational instrument for efficiency and control.[41]

Within the EU, the utilization of automated surveillance technologies is guided by a dense body of law, mostly reflected in the European Integrated Border Management (EIBM) Framework. The EIBM Framework links the operational dimension of border control to binding principles of necessity, proportionality, fundamental-rights compliance, and data-protection-by-design. It operates through interconnected systems such as EUROSUR, CISE,[42] and Copernicus,[43] which enable data exchange and situational awareness across Member States. Regulation (EU) 2019/1896 requires that all surveillance and risk-analysis activities be carried out "with full respect for fundamental rights,"[44] while oversight is exercised by the European Data Protection Supervisor and Frontex's Fundamental Rights Officer.[45] This model demonstrates how the EU conceives technological integration, i.e. as Raimondo notes, "a model of integrated technological governance tempered by rights-based oversight."[46]

On the other hand, other regional frameworks tend to prioritise coordination and operational readiness over rights-based oversight. The United States, for instance, frame AI's integration in maritime security primarily through inter-agency cooperation and rapid threat response, as reflected in their National Maritime Domain Awareness Plan (NMDAP, 2021) and Unmanned Systems Strategic Plan (2020–2030).[47] This Plan identifies uncrewed aerial and surface systems as "force multipliers" and calls for the integration of AI-enabled analytics and advanced data-management tools to support detection, tracking and targeting across mission areas.[48] Complementing these doctrinal frameworks, the Department of Homeland Security's Science and Technology Directorate has developed machine-learning platforms—such as Kestrel—that fuse multiple sensor streams and apply automated behavioural analysis to

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[41] Alex Engler, 'The EU and U.S. diverge on AI regulation: A transatlantic comparison and steps to alignment' (April 2023, Brookings Institution,) https://www.brookings.edu/articles/the-eu-and-us-diverge-on-ai-regulation-a-transatlantic-comparison-and-steps-to-alignment/, accessed 5 November 2025.

[42] CISE (Common Information Sharing Environment) is the EU framework for information exchange among authorities engaged in maritime surveillance, linking systems such as EUROSUR, SafeSeaNet and Copernicus.

[43] Copernicus is the European Union's Earth observation programme, providing satellite and in-situ data to support environmental monitoring, maritime surveillance, and border-management operations. See European Commission, Copernicus: Europe's Eyes on Earth (Copernicus Programme, 2024), https://www.copernicus.eu, accessed 7 November 2025.

[44] Regulation (EU) 2019/1896 of the European Parliament and of the Council on the European Border and Coast Guard [2019] OJ L 295/1, art 10(1).

[45] European Data Protection Supervisor (EDPS), Opinion 3/2022 on the European Border and Coast Guard Regulation (EDPS 2022).

[46] Giulia Raimondo, 'The European Integrated Border Management: Frontex, Human Rights, and International Responsibility' (Hart 2024), 15-19

[47] US Department of Homeland Security, National Maritime Domain Awareness Plan for the National Strategy for Maritime Security (December 2021); US Coast Guard, Unmanned Systems Strategic Plan 2020–2030 (USCG 2020).

[48] US Coast Guard, Unmanned Systems Strategic Plan 2020–2030 (USCG 2020), https://www.dco.uscg.mil/Portals/9/DCO%20Documents/USCG-DCO-Unmanned-Systems-Strategic-Plan-v(2025-03-20)-508-Compliant.PDF, accessed 24 November 2025.

improve real-time maritime threat evaluation.[49] These policies expand surveillance capabilities through AI, autonomous systems, and big-data analytics, yet they remain focused on operational efficiency rather than legal accountability or rights protection.[50]

The situation is similar in the wider Asia–Pacific region, where the integration of AI into maritime security has progressed primarily through national security agencies and multinational MDA partnerships. For example, Singapore's Information Fusion Centre (IFC) integrates inputs from AIS, radar, satellite imagery, and a network of multinational reporting nodes to produce a near real-time maritime picture, supporting anomaly detection and coordinated responses.[51] Another significant development in the region is the Indo-Pacific Partnership for Maritime Domain Awareness (IPMDA), a US-Indo-Pacific Initiative launched by the Quadrilateral Security Dialogue (Quad) in 2022. It provides partner States across the Indian Ocean, Southeast Asia and the Pacific with near–real time maritime surveillance by integrating satellite datasets, commercial radio-frequency analytics and information fusion centres in India, Singapore, Vanuatu and the Solomon Islands.[52] Yet despite these expanding technical capabilities, the IPMDA remains focused primarily on strategic and operational objectives, engaging with legal and geopolitical concerns as long as they relate to information-gathering in territorial seas and disputed areas, while offering no equivalent rights-based safeguards or oversight mechanisms.[53]

2.4. Conclusion

This chapter has analysed the role of AI in maritime surveillance from both, technological and institutional perspective. The first section introduced the concept of AI and its application in automated surveillance, emphasizing on how data-driven systems enhance observation, analysis, and decision-making. The following section examined the evolution of the concept of MDA and then highlighted how AI tools are being developed to support its implementation. Technologies such as AIS, LRIT, SAR, and drone systems enable large-scale monitoring but also raise legal challenges concerning data integration and human oversight. The last section explored the institutional and governance frameworks and the main technical characteristics of AI, the emergence of a "two-speed" system between technologically advanced and dependent States, and the divergent regional approaches to AI integration. Together, these analyses demonstrate that while AI increases the efficiency and precision of maritime security

[49] Department of Homeland Security Science and Technology Directorate, ' ST Modernizing Threat Alerts Using Artificial Intelligence', https://www.dhs.gov/science-and-technology/news/2025/04/29/feature-article-st-modernizing-threat-alerts-using-artificial-intelligence, accessed 24 November 2025.
[50] Abigail R Hall and Christopher J Coyne, 'The Militarization of U.S. Domestic Policing' (2013) 17(4) The Independent Review 485, 487–489
[51] Ministry of Defence (Singapore), 'Fact Sheet: Information Fusion Centre' (14 May 2019) https://www.mindef.gov.sg/news-and-events/latest-releases/14may19_fs/\, accessed 24 November 2025.
[52] Xidi Chen, Xudong Zhang and Qi Xu, 'The implications of the Indo-Pacific Partnership for Maritime Domain Awareness (IPMDA) in the South China Sea: A Chinese perspective' (2024) Marine Policy 167, 1–3.
[53] Ibid 3.

operations, it also deepens existing asymmetries in capability and accountability at sea. Concluding, this raises the central question of whether existing legal regimes can accommodate the challenges of automation while ensuring compliance with international law. The following chapter examines how these developments interact with States' legal obligations under the Law of the Sea.

Chapter 3: AI-Based Maritime Surveillance under the Law of the Sea

After examining how AI-based systems are being integrated into maritime space management by reshaping the practices of surveillance at sea, this chapter turns to the normative question of whether—and to what extent—these developments align with States' obligations under the Law of the Sea (hereinafter LOS). More specifically, this section examines how the integration of AI in maritime surveillance interacts with key principles of the Law of the Sea, namely, sovereignty and coastal and flag-State jurisdiction and responsibility.

The discussion proceeds in three parts. The first one outlines the human-centred "design" of the Law of the Sea. The second part explores how automation complicates jurisdiction and responsibility and the third part assesses prospects for adapting and interpreting the existing framework to ensure technological compliance with LOS.

3.1. The Human-centred architecture of the Law of the Sea

The LOS was mainly developed in an era when navigation and enforcement at sea were guided only by human command and clear state control. When the 1982 United Nations Convention on the Law of the Sea (hereinafter UNCLOS) was drafted, maritime navigation, enforcement and surveillance were premised on the presence of crews, masters and identifiable decision-makers acting under a flag State's authority.[54] This human-centred architecture is reflected in several provisions of UNCLOS that explicitly presuppose the presence of human actors exercising judgment and command at sea. Articles 29 and 94 of UNCLOS refer to ships being commanded by masters and manned by crews subject to discipline and training,[55] while Article 98 assigns duties directly to the master of a vessel to render assistance to persons in distress.[56] Similarly, Article 101 defines piracy through acts committed by the crew or passengers of a ship, assuming that maritime conduct is carried out by identifiable human agents.[57]

Furthermore, two of the main principles of LOS, complementary to each other, are sovereignty and the practical application of sovereignty, control. Under Articles 91-94 UNCLOS, each ship must possess a "genuine link" with a flag State, and that State must "effectively exercise its jurisdiction and control in administrative, technical and social matters."[58] This provision presupposes, that there is a chain of human responsibility—from policymakers to captains—through which accountability can be traced. Yet autonomous or semi-autonomous vessels, which are examined later in the chapter, challenge this

[54] United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 3, arts 91–94.
[55] UNCLOS, arts 29, 94.
[56] UNCLOS, art. 98.
[57] UNCLOS, art. 101.
[58] UNCLOS, arts 91-94.

anthropocentric design, because the "master" and "crew" functions may be replaced by algorithmic agents, remote operators or system manufacturers who are not physically present on board.[59] This results in a diversification between legal and actual control, creating uncertainty over how flag-state responsibility should be attributed when an AI system implements maritime decisions.

Similar problems arise due to the existing definitions in LOS of "ship"[60] and "vessel".[61] Some scholars argue that the terms "ship" or "vessel" are also applicable to unmanned systems at sea,[62] and that in most situations, the rules that regulate activities of surface ships, submarines and aircraft, operated by humans, apply *mutatis mutandis* to unmanned systems operating in the same space.[63] However, even though UNCLOS does not name the human crew of a ship as a necessary element of its legal concept, it implies human operation in provisions on navigation, communication and manning.[64] For example, Article 94(4)(b) of UNCLOS still requires that "each ship is captained by a master and officers of appropriate qualifications," which presupposes human decision-making in areas such as navigation, steering and communication.[65]

The human-centred design of the Law of the Sea becomes even clearer when examining how UNCLOS allocates obligations to States. More specifically, the structure of the convention requires states to take reasonable measures – through human judgement, qualified personnel and effective oversight—to ensure compliance with their responsibilities at sea. This reflects the due diligence nature of State obligations under UNCLOS.[66] As the International Court of Justice (ICJ) stated in the Corfu Channel case, "every State is under an obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States."[67] For example, in Article 98 the duty to promote adequate search and rescue services has been interpreted as a due diligence obligation, requiring States to "deploy all adequate means, exercise best possible efforts, do the utmost, to obtain this result".[68] Such a standard is primarily human-centred, as "adequate means" and "best possible efforts" presuppose human discretion and judgment. However, these human-centred assumptions

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[59] Linlin Chen, 'Maritime Rights, Obligations and Liabilities of Intelligent Ships from the perspective of risk Distribution', (2023) Informa UK Limited, trading as Taylor & Francis Group, 5.
[60] International Convention for the Prevention of Pollution from Ships (adopted 2 November 1973, entered into force 2 October 1983) 1340 UNTS 184, art 2(4).
[61] Convention on the International Regulations for Preventing Collisions at Sea (adopted 20 October 1972, entered into force 15 July 1977) 1050 UNTS 16, Rule 3(a).
[62] Viatcheslav Gavrilov & Roman Dremliuga, 'Major Issues of International Laws for Maritime Autonomous Vessels' Navigation (2024) 9 Research in Marine Sciences, 445-446.
[63] Kraska, J. 2010, 'The Law of Unmanned Naval Systems in War and Peace', Journal of Ocean Technology, 5(3), 44-68.
[64] Viatcheslav Gavrilov & Roman Dremliuga (n 62), 446
[65] UNCLOS, art. 94/4/b.
[66] Responsibilities and Obligations of States With Respect to Activities in the Area (Advisory Opinion) ITLOS Reports 2011, 10.
[67] Corfu Channel (United Kingdom v Albania) (Merits) [1949] ICJ Rep 4, 22.
[68] Natalie Klein, 'International laws on boat migration: An appraisal of aerial MAVs under the law of the sea, human rights law and the law on migrant smuggling' (2021) Marine Policy 127, 104447, 4

create structural tension once maritime operations begin to rely on automated or remote systems that do not fit easily within LOS's traditional structure.

It is in this context that the emergence of Maritime Autonomous Surface Ships (MASS) represents a disruption to this human-centred architecture. The IMO has classified MASS across four levels of autonomy, ranging from ships with automated decision-making (ADM) tools to fully autonomous vessels capable of making and implementing navigational choices without human input.[69] While the first two levels of this classification maintain some degree of human presence on board, the third and the fourth level directly challenge the assumptions embedded in UNCLOS regarding on board command and supervision. At these higher levels of autonomy, the functional "master" may be located in a remote operations centre (ROC) situated outside the flag State's territory or may consist of ADM processes.[70] If the core decision-making occurs in another jurisdiction or from self-learning systems, then how does the flag State effectively exercise administrative and technical control?

3.2. AI-Based Surveillance, Jurisdiction and Responsibility under LOS

In order to answer this question, it must be examined whether these new technologies actually alter the way "jurisdiction" and "responsibility" are understood under the Law of the Sea. While these technologies expand States' practical ability to detect and interpret activities at sea, they also create new forms of distributed control, algorithmic interpretation and inter-agency involvement that, at first sight, do not align with UNCLOS's traditional framework. The following two subsections examine these challenges, as far as jurisdiction and responsibility is concerned.

3.2.1. Automation and Jurisdiction under the Law of the Sea

Jurisdiction under the Law of the Sea is traditionally organised around specifically defined maritime zones, each accompanied by distinct allocations of competence. Coastal States exercise full sovereignty in their internal waters and territorial sea,[71] enjoy limited functional jurisdiction in the contiguous zone,[72] and hold specific sovereign rights with defined enforcement powers in the Exclusive Economic Zone (EEZ).[73] As far as the continental shelf is concerned, their authority is limited to sovereign rights over the exploration and exploitation

[69] IMO, 'Outcome of the Regulatory Scoping Exercise for the use of Maritime Autonomous Surface Ships (MASS)' MSC.1/Circ. 1638 (25 May 2021).
[70] Dong, Bautista and Zhu, 'Autonomous ships and flag State: challenges and opportunities in international maritime law', Journal of Transportation Security 18(1) (2024), 3–4.
[71] United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 397 (UNCLOS), art 2(1)-2(3), art. 3.
[72] UNCLOS, art. 33.
[73] UNCLOS, arts. 56 and 73.

of its seabed natural resources.[74] This zonal system presupposes that what a State is legally entitled to do at sea is constrained by geography, irrespective of its factual ability to monitor or reach particular areas.

AI-based maritime surveillance systems disturb this existing balance by literally expanding what States can "see" beyond their maritime zones, without however, altering their jurisdictional titles. Afterall, this is the main reason for a State to enhance its MDA—to seek accurate information, intelligence, surveillance, and reconnaissance concerning vessels, cargo and people, extending traditional maritime boundaries [75]. Although such strategies do not modify the existing legal framework, the practical effect could be a form of "jurisdiction at a distance", allowing coastal States to observe, classify and prioritise vessels operating in areas where their enforcement powers remain legally restricted. An ideal example are contemporary MDA practices, such as Australia's 1000-nautical-mile Maritime Identification Zone (MIZ), which definitely do not fit within the existing UNCLOS framework and "challenge its zonal approach" by enabling States to gather and act upon information originating on the high seas.[76]

Beyond these maritime zones lie the high seas, where vessels operate under the regime of freedom of navigation, principle of non-appropriation and fall, in principle, under the exclusive jurisdiction of their flag State pursuant to Articles 87, 89 and 92 UNCLOS. Coastal-State interference with foreign vessels in this area is permissible only in certain circumstances—such as piracy, slave trade, unauthorised broadcasting, stateless vessels, or hot pursuit under Article 110 and 111 UNCLOS. Automation also affects the balance between coastal-State and the exclusive jurisdiction of the flag State on the high seas. AI-based tools such as deep-learning models applied to AIS and satellite data allow States, as mentioned, to identify "abnormal" vessel behaviour—including "dark" vessels, irregular routing or prolonged loitering—across vast ocean spaces.[77] When such classifications occur in multinational MDA networks, they may end up influencing the actions of third States, despite those States having no legal basis to step in. In practice, this weakens the exclusivity of flag-State control by enabling other States to shape how a vessel is perceived and monitored before the flag State is even aware of the classification.

To conclude, this transnational architecture does not alter the legal limits of coastal-State or flag-State jurisdiction, but it does complicate their functional operation, blurring the

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[74] UNCLOS, arts. 76 and 77.

[75] US Department of Homeland Security, National Plan to Achieve Maritime Domain Awareness (October 2005), p. ii, https://www.dhs.gov/sites/default/files/publications/HSPD_MDAPlan_0.pdf, accessed 14 November 2025.

[76] Sofia Galani and Sir Malcolm D Evans, 'The Interplay between Maritime Security and the 1982 UN LOSC: help or hindrance?', (Edward Elgar 2021), 21, https://www.researchgate.net/publication/339022925_The_interplay_between_maritime_security_and_the_1982_United_Nations_Convention_on_the_Law_of_the_Sea_help_or_hindrance, accessed 22 November 2025: Australia's Maritime Identification Zone (MIZ) is a unilateral maritime security policy under which Australia requires advance identification and reporting by vessels operating beyond its territorial sea, without constituting a maritime zone recognised under UNCLOS.

[77] Kashif Talpur and others, 'AI in Maritime Security: Applications, Challenges, Future Directions, and Key Data Sources' (2025) 16 Information 658, 6–7

boundary between lawful maritime situational awareness and the indirect projection of control. These tensions set the stage for the following section, which examines how automation affects the attribution of responsibility and the fulfilment of due diligence obligations under the LOS framework.

3.2.2. Automation and Responsibility under the Law of the Sea

Whereas jurisdiction is about the right of the legal authority to act, responsibility concerns the justification for action. It asks whether the State acted reasonably on the basis of reliable information. UNCLOS defines responsibility around the conduct of States acting through vessels, officials and agents, relying on notions of "effective control" and "due diligence" that presuppose human-centred oversight.[78] Automation, as expected, complicates the exercise of these duties, but it does not displace them. Instead, it introduces uncertainty in how conduct is attributed and in whether coastal and flag States meet the standard of care that the Law of the Sea expects.

One of the first major issues arises from the operational control of autonomous and semi-autonomous systems. Work undertaken within the IMO's Regulatory Scoping Exercise (RSE) has highlighted significant gaps and uncertainties in the current framework for MASS,[79] particularly concerning the absence of crew and the emergence of Remote Operators and ROCs.[80] The deployment of high-automation vessels, namely level 3 and 4 of MASS, introduces additional actors such as system manufacturers, intelligent-system suppliers and shore-based operators (SBOs), whose roles are not defined in the traditional law of the sea.[81] These developments give rise to what has been described as a "decentralisation of operational control,"[82] which creates uncertainty over who performs functions, traditionally assigned to the master or crew, and complicates the flag State's ability to fulfil its obligations under Article 94 UNCLOS.

The implications of this decentralisation are most visible in debates on the "genuine link" and the allocation of responsibilities, mainly, in remote operating contexts. At the same time, it has to be taken into consideration, that AI-based classification tools used in maritime surveillance have frequently generated false positives and context-insensitive assessments, particularly when detecting abnormal vessel behaviours.[83] These technological limitations

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[78] UNCLOS, arts 94(1)– (6).
[79] International Maritime Organization (IMO) (2021) Outcome of the regulatory scope exercise for the use of maritime autonomous surface ships (MSC.1/Circ.1638
[80] Ruth García-Llave, Fabio Héctor Echeverry Andrade and Daniel José Coronil Huertas, 'Autonomous Ships and Flag State: Challenges and Opportunities in International Maritime Law' (2025) 18 Journal of Transportation Security, 15–17.
[81] L Chen, 'Maritime Rights, Obligations and Liabilities of Intelligent Ships from the Perspective of Risk Distribution' (2024) Journal of International Maritime Safety, Environmental Affairs, and Shipping, 3–5.
[82] Ruth García-Llave, Fabio Héctor Echeverry Andrade and Daniel José Coronil Huertas (n 80), 16.
[83] Chamali Gamage and others, 'A Comprehensive Survey on the Applications of Machine Learning Techniques on Maritime Surveillance to Detect Abnormal Maritime Vessel Behaviors' (2023) 22 WMU Journal of Maritime Affairs, 449–455.

intersect with operational risks highlighted in the MASS context, such as software failures, loss of connectivity with ROCs, or vulnerability to cyber-attacks, all of which can cause vessels to behave unpredictably and lose their ability to exercise effective oversight. Such situations expose gaps in the allocation of duties between the flag State, the remote operator and the coastal State, especially when decision-making occurs outside the State's jurisdiction or is distributed across different actors.[84] As Klein notes, however, responsibility may still be engaged when a State gains technological awareness through remote or automated systems, since any form of mediated detection can amount to factual control under the law of the sea.[85]

Overall, this section suggests that the introduction of autonomous systems and AI-based surveillance places additional pressure on how States meet their longstanding responsibilities under UNCLOS. The combination of decentralised decision-making, new operational actors and the fallibility of automated detection tools make it more difficult to determine who is actually exercising control at any given moment, and whether the information guiding maritime decisions is sufficiently reliable. While none of this displaces the legal framework of responsibility, it complicates its practical application. Assessing whether a State has acted reasonably or exercised appropriate oversight becomes less straightforward when situational awareness may depend on remote operations or algorithmic outputs. The challenges seen in both MASS operations and AI-based surveillance, therefore, point to a widening gap between UNCLOS's human-centred assumptions and the technology-mediated reality of modern maritime governance, which the next section addresses by examining possible interpretive pathways for adapting LOS to these technological changes.

3.3. Prospects for Compliance within the Existing LOS Framework

While UNCLOS constitutes the most widely used legal foundation for maritime order, the new technological challenges limit the interpretative boundaries of its core concepts. This section, therefore, examines the extent to which the existing framework can be adapted or supplemented to ensure technological compliance within LOS, while also considering whether an exclusive focus on UNCLOS is sufficient in light of recent developments in the maritime security field.

[84] Ruth García-Llave, Fabio Héctor Echeverry Andrade and Daniel José Coronil Huertas, 'Autonomous Ships and Flag State: Challenges and Opportunities in International Maritime Law' (2025) 18 Journal of Transportation Security, 15

[85] Natalie Klein, 'Maritime Autonomous Vehicles and International Laws on Boat Migration: Lessons from the Use of Drones in the Mediterranean' (2021) 127 Marine Policy 104447, 3–4

3.3.1. The limits of UNCLOS in accommodating AI-based maritime surveillance

Drafted in 1982, it was very difficult for UNCLOS not to presuppose human-centred navigation, territorially anchored control and identifiable actors exercising command at sea. However, as discussed in the previous sections, these features align poorly with contemporary systems driven mainly by remote operations, AI-based systems and transnational information infrastructures. Recent scholarship is therefore constantly questioning whether UNCLOS remains "fit for purpose" in addressing modern maritime security challenges, pointing to gaps in its ability to respond to threats that were unimaginable at the time of its negotiations, such as cyberattacks, fully autonomous vessels and complex data-driven surveillance systems.[86]

A similar concern is expressed by the UK House of Lords International Relations and Defence Committee in its report titled "UNCLOS: the Law of the Sea in the 21st Century". The report acknowledged the continuing importance of UNCLOS as a foundational legal framework, while also noting that a number of contemporary challenges, especially those arising from technological developments, were not fully envisaged at the time of its adoption and pose therefore challenges for the application of existing jurisdictional frameworks.[87] As Bueger, Edmunds and Stockbruegger discuss in their recent publication, criticising UNCLOS too heavily risks obscuring the broader set of institutions and practices through which maritime security is actually governed. Focusing solely on this convention—what they describe as "UNCLOS-centrism"—does not capture the broader picture of maritime security governance, which includes UN bodies, regional organizations, informal cooperation mechanisms, NGOs and technical infrastructures.[88]

However, is there any "room" for reinterpretation when it comes to UNCLOS? While broad concepts such as due diligence and effective control offer a degree of flexibility — as they evolve with available means, rely on functional rather than spatial control, and historically allow some interpretive discretion [89] — this flexibility is limited by UNCLOS's human-centred assumptions and cannot absorb the systemic challenges posed by AI and automation. Since many of the Convention's core provisions presuppose a human operator

[86] Christian Bueger, Timothy Edmunds and Jan Stockbruegger, 'UNCLOS under Fire: Recalibrating Maritime Security Governance' (2025) 74(Supp) ICLQ, 87–88, https://doi.org/10.1017/S0020589325101218, accessed 19 November 2025.
[87] UK House of Lords International Relations and Defence Committee, 'UNCLOS: the Law of the Sea in the 21st Century' (2nd Report of Session 2021–22, HL Paper 159, 1 March 2022) paras 25–31.
[88] Christian Bueger, Timothy Edmunds and Jan Stockbruegger, 'UNCLOS under Fire: Recalibrating Maritime Security Governance' (2025) 74(Supp) ICLQ, 87–88, https://doi.org/10.1017/S0020589325101218, accessed 19 November 2025.
[89] Seline Trevisanut, 'Search and Rescue Operations in the Mediterranean: Responsibilities and Challenges' (2014) Netherlands International Law Review, 12–15

and physical command structures, it is definitely not simple to transpose them onto AI-based systems without undermining the logic of the convention.[90]

Likewise, Syful Islam's work on emerging monitoring technologies highlights that existing maritime treaties—including UNCLOS—provide no standards for the reliability of AI-generated classifications, leaving significant uncertainty when such data provoke enforcement decisions.[91] These structural gaps cannot be resolved through interpretation alone. Therefore, attempting to rework UNCLOS, in order to absorb every contemporary challenge, risks reproducing "UNCLOS-centrism" and overlooking the much broader set of institutions and practices that shape modern maritime security governance.[92] In a few words, these perspectives suggest that stretching UNCLOS to accommodate new technologies is not only legally strained but also strategically false, given that more adaptive and technologically responsive mechanisms already exist within the wider maritime governance landscape.

In conclusion, the limits of UNCLOS are not interpretative but structural. The Convention can accommodate certain technological developments through flexible standards such as due diligence and functional understandings of control, but it cannot provide comprehensive responses to the data-driven and transnational character of contemporary maritime security. Ensuring technological compliance therefore requires looking beyond UNCLOS and engaging with the wider governance landscape, i.e. IMO processes, regional surveillance regimes, operational practice and soft-law instruments, which shape how maritime activities are monitored.

3.3.2. The adaptive potential of the wider maritime legal framework

Since UNCLOS can help tackle contemporary maritime security threats only to a limited extent,[93] which are these more adaptive and technologically responsive mechanisms that already operate within the wider maritime security landscape? This question reflects what Bueger and his co-authors describe as an 'assemblage' approach to maritime security governance, in which technological systems, institutions, legal instruments and operational practices interact across multiple layers rather than within a single treaty framework.[94] Within this assemblage, adaptation often takes place through mechanisms that are more flexible and practice-oriented than UNCLOS itself. These mechanisms can rapidly evolve in response to

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[90] S Gavrilov and I Dremliuga, 'Major Issues of International Laws for Maritime Autonomous Vessels' Navigation' (2024) Research in Marine Sciences 27, 29–31

[91] Syful Islam, 'Legal Implications of Emerging Technologies in Maritime Pollution Monitoring and Management' (2024) J Indian Ocean Region, 55–59

[92] Christian Bueger, Timothy Edmunds and Jan Stockbruegger, 'UNCLOS under Fire: Recalibrating Maritime Security Governance' (2025) 74(Supp) International and Comparative Law Quarterly 85, 87-89

[93] Sofia Galani and Sir Malcolm D Evans, 'The Interplay between Maritime Security and the 1982 UN LOSC: help or hindrance?', (Edward Elgar 2021), 24, https://www.researchgate.net/publication/339022925_The_interplay_between_maritime_security_and_the_1982_United_Nations_Convention_on_the_Law_of_the_Sea_help_or_hindrance, accessed 22 November 2025.

[94] Christian Bueger, Timothy Edmunds and Jan Stockbruegger (n 92), 90–96.

operational needs, allowing them to integrate new technologies long before any formal treaty reform is considered.

Firstly, it should be emphasized that much of the contemporary governance of maritime security takes place within the wider UN system rather than through UNCLOS alone. Bodies such as the IMO, FAO and the UNODC regulate operational safety, fisheries management, maritime crime, and the treatment of migrants at sea in ways that evolve far more quickly than treaty law. These institutions possess the ability to regularly update technical standards, monitoring practices and enforcement frameworks, illustrating that the UN's regulatory capacity exceeds the interpretative limits of UNCLOS. An example of IMO's relatively rapid adaptation is the 2019 approval of interim guidelines for MASS trials, followed by a 2021 RSE assessing existing instruments for ships with varying degrees of automation, which were mentioned above. In its work on MASS, the IMO has acknowledged that existing international maritime conventions, including SOLAS, the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs) and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), were drafted on the assumption of human-operated vessels and may not fully accommodate autonomous or highly automated technologies. Rather than displacing the existing legal framework, the IMO has emphasized the need to interpret or adapt current instruments in the light of technological developments, highlighting a practice-oriented approach to regulatory evolution.[95]

Beyond the IMO system, other UN institutions within the wider maritime governance landscape have also adapted rapidly to technological change. The FAO, for instance, has strengthened efforts against illegal, unreported and unregulated (IUU) fishing by supporting regional fisheries management organisations (RFMOs) in developing national vessel-monitoring systems (VMS), and by establishing a centralised RFMO satellite-based VMS for the high seas, where the utility of AIS is being examined as a complementary monitoring tool.[96] Additionally, the UNODC plans to expand its Global Maritime Crime Programme (GMCP) to a further 67 countries, bringing the total number of participating States to 109. These States receive training in digital evidence collection, surveillance technologies and operational coordination tools.[97]

Beyond the UN system, many other regional organizations have proved far more agile than UNCLOS in integrating new surveillance technologies. In the EU, the European Commission adopted in 2021 an Implementing Regulation (EU) 2021/581 on the situational pictures of EUROSUR, which standardises data-layers and mandates automated processing of

[95] IMO, 'Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships' (MASS) (MSC 102/5/1, 2021).
[96] Holly Koehler, 'RFMO Vessel Monitoring Systems: A Comparative Analysis to Identify Best Practices', (ISSF Technical Report 2022-06, International Seafood Sustainability Foundation Washington, DC 2022), 7.
[97] UN Office on Drugs and Crime, 'Global Maritime Crime Programme (GMCP)' https://www.unodc.org/unodc/en/piracy/gmcp-homepage.html, accessed 22 November 2025.

information derived from sensors and platforms.[98] In practice, the EUROSUR Fusion Services, coordinated by Frontex, now aggregate intelligence from satellites, drones and other surveillance technologies, and provide automated vessel tracking, anomaly detection and AI-based threat analysis,[99] while Copernicus Border Surveillance Services develop digital-twin models of the external borders to support border and maritime surveillance.[100] A further example of technological adaptability is the Regional Cooperation Agreement on Combating Piracy and Armed Robbery against Ships (ReCAAP) Information Sharing Centre (ISC), which has become a central hub for maritime situational awareness in Asia. According to its 2023 Annual Report, the ISC operates a secure web-based information network linking national focal points and enabling real-time incident reporting and alert dissemination.[101]

While none of these arrangements could possibly replace UNCLOS or resolve the full range of legal questions raised by automation and AI-based surveillance, they demonstrate that contemporary maritime governance is shaped by a much wider constellation of institutions and mechanisms. Ignoring this broader landscape would obscure the practical realities through which technological adaptation is already occurring. It is therefore necessary to adopt the "assemblage approach" outlined above, recognising that the legal implications of emerging technologies cannot be understood through UNCLOS alone.

3.4. Conclusion

This chapter has shown that AI-based maritime surveillance places constant pressure on the human-centred assumptions that characterize the traditional Law of the Sea. UNCLOS was drafted around clear chains of human authority and territorially anchored control, yet automated systems, remote operations and algorithmic decision-making complicate how jurisdiction and responsibility are exercised in practice. The diversification of operational roles, the fallibility of AI-generated classifications and the emergence of actors operating outside the vessel, or even the flag State's jurisdiction blur the allocation of effective control and make assessments of due diligence even more difficult. These developments do not displace the existing responsibility framework, but they make its application uncertain.

At the same time, the structural limits of UNCLOS constrain its capacity to adapt to these technological shifts. Although flexible notions such as due diligence and functional control provide some room for reinterpretation, they cannot and there is actually no need to

[98] Commission Implementing Regulation (EU) 2021/581 of 9 April 2021 on the situational pictures of the European Border Surveillance System (EUROSUR) [2021] OJ L 124/3.
[99] European Commission, "EUROSUR Fusion Services" (Migration and Home Affairs), available at: https://home-affairs.ec.europa.eu/policies/schengen/eurosur_en, accessed 22 November 2025
[100] Copernicus EU, 'Driving Innovation in Border Surveillance: Copernicus Digital Twins' (2024) https://www.copernicus.eu/en/news/news/observer-driving-innovation-border-surveillance-copernicus-digital-twins, accessed 22 November 2025.
[101] ReCAAP Information Sharing Centre, Annual Report 2023 (ReCAAP ISC, Singapore, 2024), https://www.recaap.org/resources/ck/files/reports/annual/ReCAAP%20ISC%20Annual%20Report%202023.pdf, accessed 22 November 2025.

fully accommodate systems premised on remote operation, data-driven classification and transnational information infrastructures. As a result, focusing only on UNCLOS risks obscuring the wider constellation of institutions, practices and technical mechanisms through which maritime security and maritime border management is actually governed. The chapter therefore concludes that ensuring technological compliance cannot depend on treaty interpretation alone but requires engagement with the broader maritime governance landscape—including other UN bodies (IMO, FAO, UNODC) and also other regional mechanisms (ReCAAP, EUROSUR)—that can adapt more rapidly to technological change.

Chapter 4: AI-Based Maritime Surveillance under International Human Rights Law

The digitalisation of border management is not a new phenomenon.[102] For more than two decades, States and international organisations have relied on databases and biometric systems, such as travellers' identification tools, to strengthen situational awareness and regulate cross-border mobility. Yet AI marks a distinct transformation in this trajectory. What had once been digital border control—largely limited to data processing and basic automation—is evolving into a form of "smart" digital border governance, characterised by predictive analytics, automated classification, and algorithmic decision-support.[103] As shown in the previous chapters, these developments now shape maritime surveillance as much as they do land borders, enabling authorities to detect, track, and evaluate vessels and the people on board with unprecedented speed and granularity.

Building on this foundation, the present chapter turns to the implications of these transformations for International Human Rights Law (hereinafter IHRL). While Chapters 2 and 3 demonstrated how AI-based surveillance expands States' factual ability to monitor maritime spaces and how it complicates the exercise of jurisdiction and responsibility under LOS, these technological developments also carry significant implications for the protection of individuals at sea. Accordingly, this chapter first outlines the applicability of human-rights obligations in maritime contexts, before assessing the specific rights most affected by AI-based technologies—privacy, non-discrimination, the right to life and rescue, non-refoulement, and due process. The chapter concludes by examining the potential for compliance between AI and IHRL.

4.1. The Applicability of IHRL at Sea in the Age of AI

IHRL applies at sea through a combination of territorial jurisdiction, flag State jurisdiction, and the broader principle of effective control. While coastal States bear human-rights obligations in their internal waters and territorial sea, the legal position becomes more complex in the contiguous zone, the EEZ, and on the continental shelf.[104] On the high seas, where no State enjoys territorial sovereignty, vessels fall under the exclusive jurisdiction of their flag State, with limited exceptions, according to article 92 UNCLOS.[105] Additionally, article 94 further requires each State to "effectively exercise its jurisdiction and control in administrative, technical and social matters", implying human rights protection over ships flying its flag.[106]

[102] Rinaldi and Teo, 'The Use of Artificial Intelligence Technologies in Border and Migration Control and the Subtle Erosion of Human Rights' (2025) 74 International and Comparative Law Quarterly, 62.
[103] Ibid.
[104] Sofia Galani, 'Human Rights Obligations in Maritime Search and Rescue' (2025) 74 ICLQ 33, 39-40.
[105] UNCLOS (1982) art 92.
[106] UNCLOS, art 94.

Beyond these territorial or flag-based connections, IHRL also applies wherever a State exercises *de facto* authority or effective control over individuals encountered at sea. This has been affirmed by the European Court of Human Rights (ECtHR) in cases such as *Medvedyev v France*, where individuals on a Cambodian-flagged vessel under the exclusive control of French naval forces were held to fall within France's jurisdiction,[107] and in *Hirsi Jamaa v Italy,* where migrants intercepted on the high seas were found to be under Italy's continuous and exclusive de facto control.[108] This jurisprudence reflects a growing consensus that human-rights obligations apply whenever State agents—whether coastal or flag State authorities—exercise powers capable of determining the situation of individuals at sea.[109]

A central question emerging from this framework is whether, and if so how, AI-based surveillance can trigger States' human-rights obligations at sea. As examined in Chapter 2, modern maritime surveillance relies on automated vessel detection, multimodal data fusion, predictive analytics, and algorithmic risk assessments, allowing States to identify, monitor, and classify vessels long before any physical encounter occurs.[110] These systems may generate alerts, flag certain vessels as suspicious, or recommend specific operational responses, thereby influencing whether authorities decide to intercept, divert, or assist individuals at sea.[111] In this sense, AI does not merely support but effectively participates in the decision-making process through which States exercise control over individuals.[112] When State agents rely on AI-generated outputs to shape operational choices, they may effectively determine the situation of persons on board, thereby bringing those individuals within the State's jurisdiction for the purposes of IHRL.[113] Even without immediate physical contact, AI-based surveillance could therefore trigger human-rights obligations whenever it directs or substantially influences how States respond to vessels and the people on board.

These observations suggest that the use of AI in maritime surveillance may engage human-rights obligations in ways that are consistent with the existing jurisdictional framework under IHRL. AI appears to influence how authority is exercised and, consequently, alter the circumstances in which individuals may fall within a State's jurisdiction. The following section, therefore, examines which specific human rights are most likely to be affected by AI-based maritime practices and the challenges this raises for their effective protection.

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[107] Medvedyev and Others v France (2010) 51 EHRR 39 [67]-[69].
[108] Hirsi Jamaa and Others v Italy (2012) 55 EHRR 21 [73]-[82].
[109] Sofia Galani, 'Human Rights Obligations in Maritime Search and Rescue' (2025) 74 ICLQ 33, 41.
[110] Talpur and others, 'AI in Maritime Security: Applications, Challenges, Future Directions, and Key Data Sources' (2025) Information 16(8) 658, 1-2, 6-7.
[111] Yiran Yang and others, 'Automated Decision-Making and Artificial Intelligence at European Borders and Their Risks for Human Rights', (2023, working draft), 2-3
[112] Alberto Rinaldi and Sue Anne Teo, 'The Use of Artificial Intelligence Technologies in Border and Migration Control and the Subtle Erosion of Human Rights' (2025) 74 ICLQ 61, 23-25.
[113] Ana Beduschi, 'International Migration Management in the Age of Artificial Intelligence' (2020) 9 Migration Studies 1, 3-4.

4.2. Human Rights Affected by AI-Based Maritime Surveillance

While, as discussed, significant questions of jurisdiction arise, when it comes to AI-based maritime surveillance, the underlying framework remains unchanged. What does change, however, is the way in which AI tools use data at sea, thereby creating new modalities of interference with a range of well-established human rights. These technologies can reshape how decisions are made, how individuals are assessed, and how State power is exercised, turning long-established protections—such as privacy, equality, and access to justice—into areas that require renewed legal scrutiny. In this context, understanding how AI-based surveillance practices intersect with specific rights—ranging from privacy and data protection to non-discrimination, the right to life and protection from refoulement—becomes essential for assessing the human-rights implications of contemporary maritime governance.

4.2.1. Privacy and Data Protection

The right to privacy is protected under both Article 17 of the International Covenant on Civil and Political Rights (ICCPR)[114] and Article 8 of the European Convention on Human Rights (ECHR),[115] which prohibit unlawful or arbitrary interferences with an individual's private life. In the jurisprudence of the ECtHR, the notion of "private life" has been interpreted broadly to include not only personal data but also the collection and processing of information through surveillance technologies.[116] Any interference with privacy must therefore be in accordance with the law, pursue a legitimate aim, and be necessary in a democratic society.[117] Transparency about how and for which purposes personal data are used also forms part of this assessment.[118] Last, because Article 8 ECHR and Article 17 ICCPR apply wherever a State exercises jurisdiction, the privacy guarantees in these instruments also govern maritime enforcement whenever territorial, flag, or effective control is exercised at sea. This interpretation aligns with the ECtHR's approach to extraterritorial jurisdiction, according to which a State that exercises control over individuals is required to secure to them the rights and freedoms guaranteed by the ECHR, as affirmed in *Hirsi Jamaa and Others v Italy.*[119]

However, the integration of AI in maritime border surveillance raises additional challenges for the protection of personal data and privacy. Biometric systems, for example, use large amounts of sensitive data, such as fingerprints, facial images and iris scans, which

[114] International Covenant on Civil and Political Rights (adopted 16 December 1966, entered into force 23 March 1976) 999 UNTS 171, art 17.
[115] European Convention on Human Rights (adopted 4 November 1950, entered into force 3 September 1953) 213 UNTS 221, art 8.
[116] S. and Marper v United Kingdom (2008) 48 EHRR 50, [67]-[68].
[117]European Convention on Human Rights, Art. 8(2).
[118] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with regard to the Processing of Personal Data and on the Free Movement of Such Data (General Data Protection Regulation) art 5(1)(a).
[119] Hirsi Jamaa and Others v Italy (2012) 55 EHRR 21, para 74.

could reveal people's ethnicity or aspects of an individual's health. The use or storage of these private data from ADM systems may constitute an interference with the right to privacy under article 8 of ECHR, if the requirements of legality-necessity-proportionality are not satisfied. [120] Moreover, when such biometric data are combined with other forms of information—such as vessel trajectories, behavioural indicators or past migration history— AI can create very detailed profiles of individuals, making the level of monitoring even more intrusive. Drone-based surveillance further expands these capacities by enabling continuous, long-range monitoring of maritime areas and by feeding large volumes of sensor data into automated analysis systems.[121] In many cases, these technologies are developed, supplied or even partly operated by private companies. Saunders highlights that data have a variety of "life cycles". Once they enter such systems, they may circulate between different public and private actors and be repurposed in ways individuals cannot anticipate, thus raising concerns about function creep and loss of control over personal information.[122]

4.2.2. Non-Discrimination

The right to non-discrimination is protected under Article 14 ECHR, Article 1 of Protocol No. 12,[123] and Article 26 of the ICCPR, each of which prohibits unequal treatment based on race, ethnicity, nationality or other personal characteristics. In IHRL discrimination may arise not only from explicit distinctions but also from measures that appear neutral yet have disproportionate effects on certain groups.[124] This broader understanding is particularly important in the context of border and migration control, where decisions can significantly affect vulnerable individuals who may have limited means of challenging how they are treated. At sea, operational measures such as vessel identification or interception practices can therefore raise discrimination concerns even when there's no discriminatory intent.[125]

AI-based maritime surveillance poses certain discrimination risks because the systems used, for instance, to detect vessels or evaluate behaviours, often reproduce patterns found in the data on which they are trained. Many of these models rely on historical enforcement records or large-scale migration datasets that already reflect assumptions about which movements should be considered "irregular", or which vessels are likely to carry migrants.[126] When these patterns are built into AI systems, the technology may disproportionately flag routes or vessel types commonly associated with migrants as "high-risk", even when there is

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[120] Yiran Yang and others, 'Automated Decision-Making and AI at European Borders and Their Risks for Human Rights' (working draft, 2023), 19
[121] Ibid 20.
[122] Natasha Saunders, 'Moving Beyond Settlement: On the Need for Normative Reflection on the Global Management of Movement Through Data' (2023) 19 Journal of Global Ethics 282, 285-289, https://doi.org/10.1080/17449626.2023.2271001, accessed 4 December 2025.
[123] Protocol No 12 to the Convention for the Protection of Human Rights and Fundamental Freedoms (adopted 4 November 2000, entered into force 1 April 2005) ETS No 177, art 1.
[124] D.H. and Others v Czech Republic (2007) 47 EHRR 3 [184]-[185]
[125] Vincent Chetail, 'International Migration Law' (OUP 2019), 356-358
[126] Yiran Yang and others, (n 120), 9-12

no objective justification for doing so.[127] These systems can also generate false positives, meaning that vessels or individuals are incorrectly identified as suspicious due to incomplete, outdated or biased datasets.[128] For example, the Dutch Ministry of Foreign Affairs used an ADM model in visa processing and disproportionately classified applicants from certain nationalities as high-risk, leading to discriminatory outcomes and its eventual withdrawal.[129] Such errors can trigger increased monitoring, early warnings or interception measures that affect certain groups more heavily than others.[130] Although these outcomes arise without any discriminatory intent, the effect is that AI tools may reinforce existing inequalities in maritime enforcement and lead to differential treatment of people on the move.[131] These indirect effects could potentially amount to a violation of Article 14 ECHR or Article 26 ICCPR where the use of AI places certain groups at a particular disadvantage without adequate justification. What matters is not whether authorities intended to discriminate, but whether the system produces unequal outcomes that cannot be shown to pursue a legitimate aim or to be proportionate to that aim.

4.2.3. The Right to Life and the Duty to Render Assistance

The right to life, as protected by Article 6 ICCPR and Article 2 ECHR, requires States to take positive measures to prevent foreseeable loss of life, including at sea. In the maritime domain, these obligations are closely connected to the duty to render assistance, which serves as a tool for the implementation of the right to life at sea.[132] More specifically, Article 98(1) of UNCLOS obliges the master of a ship, "in so far as he can do so without serious danger to the ship, the crew or the passengers," to render assistance "to any person found at sea in danger of being lost and to proceed with all possible speed to rescue persons in distress",[133] while Article 98(2) requires coastal States to "promote the establishment, operation and maintenance of an adequate and effective search and rescue service" and to cooperate regionally for that purpose.[134] Regulation 33(1) of Chapter V SOLAS similarly mandates that masters proceed to the assistance of persons in distress "regardless of the nationality or

[127] Ana Beduschi, 'International Migration Management in the Age of Artificial Intelligence' (2020) 9 Migration Studies 1, 3-5
[128] Alberto Rinaldi and Sue Anne Teo, 'The Use of Artificial Intelligence Technologies in Border and Migration Control and the Subtle Erosion of Human Rights' (2025) 74 ICLQ 61, p. 23-25
[129] Lighthouse Reports, 'Ethnic Profiling: How the Dutch Ministry of Foreign Affairs Used an Algorithm That Discriminated Against Visa Applicants' (Investigative Report, 2021), https://www.lighthousereports.com/investigation/ethnic-profiling/, accessed 5 December 2025.
[130] Yiran Yang and others, 'Automated Decision-Making and AI at European Borders and Their Risks for Human Rights' (working draft, 2023), 11-14
[131] Natasha Saunders, 'Moving Beyond Settlement: On the Need for Normative Reflection on the Global Management of Movement Through Data' (2023) 19 Journal of Global Ethics 282, 287-289
[132] Aphrodite Papachristodoulou, 'The Recognition of a Right to be Rescued at Sea in International Law' (2022) 35 LJIL, 337; Sofia Galani, 'Human Rights Obligations in Maritime Search and Rescue' (2025) 74 International and Comparative Law Quarterly 33, 38.
[133] UNCLOS, art 98(1).
[134] Ibid art 98(2).

status of such persons or the circumstances in which they are found,"[135] while the 1979 SAR Convention obliges States to establish rescue coordination centres and SAR services so that persons in distress are rescued and delivered to a place of safety, in line with IMO Guidelines.[136] Lastly, according to General Comment No. 36 of the Human Rights Committee (HRC), the right to life extends to persons in distress at sea and States must protect them "in accordance with their international obligations on rescue at sea,"[137] considering in that way the protection of the right to life at sea a due diligence obligation.[138] Similarly, in *AS and others v Italy*, the Human Rights Committee held that Italy exercised jurisdiction over individuals at sea because its actions had a "direct and reasonably foreseeable impact" on their rights.[139]

AI-based maritime surveillance complicates the fulfilment of this due diligence obligation where its design or use affects how authorities detect and respond to distress situations. Forster warns that "smart" border technologies can create "physical safety risks" when they are used primarily for enforcement rather than humanitarian purposes, including diverting resources away from rescue or encouraging movement along more dangerous routes.[140] In addition, AI-based detection systems typically identify only overt or visual indicators of danger—for example, a vessel taking on water—while established SAR practice recognises that distress may also arise from overcrowding, medical emergencies or unseaworthiness.[141] Where operational decision-making is influenced by such systems, there is a risk of automation bias, because human operators defer to algorithmic assessments and overlook conditions that legally amount to distress, leading to delayed intervention.[142] Since the right to life requires authorities to act on reasonably foreseeable threats to life at sea, such delays may undermine States' ability to fulfil their positive obligations under Article 6 ICCPR and Article 2 ECHR. This approach is supported by recent human rights scholarship. Papachristodoulou argues that contemporary maritime surveillance enables States to acquire real-time knowledge of situations involving foreseeable risks to life and to influence outcomes through remote operational decisions, including whether to initiate, coordinate or withhold

[135] International Convention for the Safety of Life at Sea (SOLAS) (adopted 1 November 1974, entered into force 25 May 1980) 1184 UNTS 3, ch V reg 33(1).
[136] International Convention on Maritime Search and Rescue (adopted 27 April 1979, entered into force 22 June 1985) 1405 UNTS 97, chs 2-3; IMO, 'Guidelines on the Treatment of Persons Rescued at Sea' MSC.167(78) (20 May 2004).
[137] UN HRC, 'General Comment No 36 on Article 6 of the International Covenant on Civil and Political Rights, on the Right to Life' (30 October 2018) UN Doc CCPR/C/GC/36 (General Comment No 36) para 63.
[138] Ibid paras 21, 63.
[139] AS, DI, OI and GD v Italy (27 January 2021) CCPR/C/130/D/3042/2017, paras 7.6-7.8
[140] Madeleine Forster, 'Refugee Protection in the Artificial Intelligence Era: A Test Case for Rights' (Chatham House Research Paper, 2022) 10-12.
[141] Jamie Hancock, Ruoyun Hui, Jatinder Singh and Anjali Mazumder, 'Trouble at Sea: Data and digital technology challenges for maritime human rights concerns' (2024) FAccT '24 Conference Proceedings 1, 6-7; Sofia Galani, 'Human Rights Obligations in Maritime Search and Rescue' (2025) 74 International and Comparative Law Quarterly 33, 47-48
[142] Ana Beduschi, 'International Migration Management in the Age of Artificial Intelligence' (2020) 9 Migration Studies 576, 587–589.

search and rescue operations.[143] In such circumstances, the relevance of the right to life cannot be limited to physical presence or custody, but must also take into account a State's capacity to affect survival prospects through surveillance-based decision-making.

4.2.4. Non-Refoulement

The principle of non-refoulement prohibits States from transferring individuals to territories where they face a real risk of persecution, torture, inhuman or degrading treatment, or other serious harm. This obligation is set out in Article 33(1) of the 1951 Refugee Convention, which provides that no State shall expel or return ("refouler") a refugee "in any manner whatsoever" to such dangers,[144] and is reinforced by the absolute prohibition of torture in Article 3 of the Convention against Torture and Article 3 ECHR.[145] In addition, Article 7 ICCPR prohibits returning an individual to places where they face a real risk of treatment contrary to that provision, as interpreted by the HRC's general comment No. 31.[146] According to the Advisory Opinion on the Extraterritorial Application of Non-Refoulement Obligations of the UNHCR, these obligations apply extraterritorially whenever a State exercises effective control over individuals, including during maritime interception or search and rescue operations.[147] The ECtHR made this clear in *Hirsi Jamaa v Italy*, holding that the interception and return of migrants on the high seas to Libya violated Article 3 ECHR and the prohibition of collective expulsion, even though the operation occurred outside territorial waters. [148]

As examined earlier in relation to the right to life, AI-based border technologies tend to prioritize enforcement-driven operational patterns, something that also raises concerns for the principle of non-refoulement. AI-based maritime surveillance can actually influence how interceptions occur, sometimes by limiting access to asylum procedures or by leading to cooperation with authorities in countries where individuals face a real risk of serious harm.[149] In addition, ADM tools used in migration management—such as those supporting language, identity or credibility assessments—have been shown to produce inaccuracies or biases that, as the European Parliamentary Research Service warns, may "jeopardise the right to asylum" and ultimately lead to the refoulement of individuals with protection needs.[150] The risk is

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[143] Aphrodite Papachristodoulou, 'The Exercise of State Power over Migrants at Sea through Technologies of Remote Control: Reconceptualizing Human Rights Jurisdiction' (2024) 73 International and Comparative Law Quarterly, 931–961.
[144] Convention Relating to the Status of Refugees (adopted 28 July 1951, entered into force 22 April 1954) 189 UNTS 137, art 33(1).
[145] Convention against Torture (adopted 10 December 1984, entered into force 26 June 1987) 1465 UNTS 85, art 3; ECHR, art 3.
[146] Human Rights Committee, General Comment No. 31: Nature of the General Legal Obligation on States Parties to the Covenant (26 May 2004) CCPR/C/21/Rev.1/Add.13, para 12.
[147] UNHCR, *Advisory Opinion on the Extraterritorial Application of Non-Refoulement Obligations* (26 January 2007) paras 24-26
[148] Hirsi Jamaa and Others v Italy App no 27765/09 (ECtHR, 23 February 2012) paras 114-158.
[149] Madeleine Forster, 'Refugee Protection in the Artificial Intelligence Era: A Test Case for Rights' (Chatham House Research Paper, 2022) 10-12.
[150] European Parliamentary Research Service, 'Artificial Intelligence in Asylum Procedures' (2023) 6-8.

heightened by the aforementioned automation bias, which may lead operators to rely uncritically on algorithmic outputs rather than conducting their own assessment required to determine protection needs.[151] Where AI-based surveillance and information-sharing practices contribute to returns or interceptions by third countries with poor human rights records, these processes may indirectly expose individuals to treatment prohibited under Article 33(1) of the Refugee Convention, Article 3 ECHR and other non-refoulement norms. In this way, AI does not alter the substance of the non-refoulement obligation but may undermine States' ability to comply with it in practice.

4.2.5. Effective Remedy and Due Process

The last right significantly affected by the integration of AI into maritime border operations concerns the guarantee of an effective remedy and the principles of due process. As the preceding sections have shown, AI-based systems can influence how States detect, classify and respond to individuals at sea, with direct implications for their substantive rights. Under Article 13 ECHR and Article 2(3) ICCPR, States must ensure that individuals have access to mechanisms capable of challenging decisions that interfere with their rights and obtaining redress where necessary.[152] In the EU context, Article 47 of the Charter of Fundamental Rights (CFR) further requires that such procedures be fair, impartial and practically accessible, while Article 41(2) CFR protects the right to be heard and the right to receive reasons for administrative decisions.[153] Ensuring these guarantees at sea is already challenging, given the speed and opacity of maritime operations. When digital systems contribute to operational decisions, the difficulty of informing individuals, enabling them to contest decisions, and providing access to the underlying evidence becomes even more apparent. For this reason, the right to an effective remedy is particularly vulnerable in AI-mediated maritime contexts.

The main way AI undermines the right to an effective remedy is by creating decisions that are difficult—or practically impossible—for individuals to understand or contest. The European Parliamentary Research Service has documented how automated tools used for identity, credibility or nationality analysis have produced inaccurate outcomes, including cases where dialect-recognition systems misidentified a person's country of origin, leading authorities to treat them as coming from a "safe" country and accelerating removal procedures.[154] Similar risks arise at sea when surveillance data or AI-generated vessel classifications are relied upon to justify interceptions or transfers without explaining how those determinations were reached. O'Sullivan points out that many AI models operate as "black boxes", relying on proprietary algorithms and undisclosed training data, meaning that

[151] Ana Beduschi, 'International Migration Management in the Age of Artificial Intelligence' (2020) 9 Migration Studies 576, 587-589.
[152] ECHR art 13; International Covenant on Civil and Political Rights (adopted 16 December 1966, entered into force 23 March 1976) 999 UNTS 171, art 2(3).
[153] Charter of Fundamental Rights of the European Union [2012] OJ C326/391, arts 41(2) and 47.
[154] European Parliamentary Research Service, 'Artificial Intelligence in Asylum Procedures' (2023) 6-7

neither individuals nor reviewing bodies, i.e. developers, can access the criteria, assumptions or error rates underpinning the decision.[155] This opacity prevents those intercepted at sea from even realising that an automated assessment has occurred, let alone understanding or contesting it.

Last, errors in algorithmic systems tend to be systemic rather than isolated, replicating the same mistake across large numbers of cases.[156] In the maritime context, this means that a flawed vessel-risk score, geospatial model or identity inference may affect entire categories of decisions, while individuals remain unaware that the process was even automated. Attempts to obtain information *ex post* are also unlikely to succeed, since freedom-of-information (FOI) mechanisms have repeatedly failed to disclose algorithmic logic in comparable systems, and maritime surveillance data is typically controlled by multiple agencies or shared with third countries, creating asymmetries.[157] These gaps become even more serious when tools, such as mobile-phone extraction, behavioural analytics or other automated practices produce incorrect or unfair inferences about a person, creating suspicion and leading to negative operational decisions that the individual has no actual way to challenge.[158] Combined with the automation bias discussed earlier, these factors significantly impair the ability of individuals to obtain reasons, to be heard, or to seek review, as required by Articles 41(2) and 47 of the CFR.

4.3. Prospects for Rights-Compatible Integration of AI under IHRL

The analysis in the previous section has established that the use of AI in maritime border surveillance and security systems raises significant challenges for a wide range of human rights. However, these challenges are not merely operational but stem from structural features of AI, such as opacity, systemic error, automation bias and fragmented responsibility that complicate the practical application of human rights obligations at sea.[159] In light of these challenges, the key question is whether the existing IHRL framework is capable of regulating or accommodating the use of AI in the maritime domain. This section does not seek to propose specific safeguards or regulatory solutions. Rather, mirroring the analytical approach adopted in Section 3.3, it examines whether the interpretive principles and institutional mechanisms of IHRL provide a flexible basis for ensuring that AI-based practices can be implemented in a manner that is compatible with States' existing human rights obligations.

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[155] Maria O'Sullivan, 'Artificial Intelligence and the Right to an Effective Remedy' in Michał Balcerzak and Julia Kapelańska-Pręgowska (eds), 'Artificial Intelligence and International Human Rights Law' (Edward Elgar Publishing 2024), 2-4.
[156] Ibid 5-6.
[157] Ibid 7-9; see also Jamie Hancock, Ruoyun Hui, Jatinder Singh and Anjali Mazumder, 'Trouble at Sea: Data and digital technology challenges for maritime human rights concerns' (2024) FAccT '24 Conference Proceedings, 6-8.
[158] European Parliamentary Research Service (n 155), 7-8
[159] Maria O'Sullivan, (n 155).

IHRL has often been understood as a framework capable of adapting to evolving forms of State action, including those involving new technologies. This adaptability derives from the way IHRL is constructed around open-textured principles, such as legality, necessity, proportionality and due diligence, rather than detailed, technology-specific rules. As Letsas observes, the ECHR was not drafted as a closed or technical code, but as a system of abstract principles whose concrete meaning must be developed through interpretation in light of changing social and factual circumstances.[160] This understanding is closely linked to the Court's characterisation of the Convention as a "living instrument", which allows human-rights norms to respond to developments not predicted by the drafters, including technological change.[161]

This structural margin for interpretation is also found in the case law of the ECHR. For instance, in *Al-Skeini v United Kingdom*, the Court emphasised that the scope of jurisdiction and the corresponding positive obligations under the Convention are not confined to traditional territorial settings, but extend to situations in which State agents, including through technologically mediated conduct, exert power over individuals' rights.[162] A comparable, technology-neutral approach can be found in the jurisprudence of the HRC. General Comment No. 31 clarifies that States' positive obligations under the ICCPR apply to all forms of State action within their power or effective control, while General Comment No. 36 affirms that the right to life entails duties of prevention and protection irrespective of the operational modalities or tools employed.[163] Institutional guidance further supports this opinion. The Council of Europe's Recommendation CM/Rec (2020)1 clearly supports that algorithmic systems fall within the scope of human-rights obligations and must be assessed against established principles of legality, accountability and oversight.[164] These developments suggest that IHRL is not, by its construction, incapable of engaging with AI. Whether this conceptual adaptability can be translated into effective protection in the maritime domain, however, remains a separate question.

At the same time, the characteristics that make IHRL adaptable in principle, also expose the limits of its application, when it comes to the use of AI. Many of the interpretive doctrines on which IHRL relies, such as foreseeability, due diligence, attribution of responsibility and access to an effective remedy, presuppose a degree of transparency,

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[160] George Letsas, 'A Theory of Interpretation of the European Convention on Human Rights' (Oxford University Press 2007) 41-45.

[161] Christos Rozakis, 'The European Convention on Human Rights as a Living Instrument' in George Letsas and others (eds), 'Human Rights in Europe: The Influence of the ECHR on National Legal Systems', (Oxford University Press 2014) 11-14.

[162] Al-Skeini and Others v United Kingdom App no 55721/07 (ECtHR, 7 July 2011) paras 131-137.

[163] Human Rights Committee, General Comment No 31: The Nature of the General Legal Obligation Imposed on States Parties to the Covenant, UN Doc CCPR/C/21/Rev.1/Add.13 (2004) paras 6-10; General Comment No 36: Article 6 (Right to Life), UN Doc CCPR/C/GC/36 (2019) paras 21-23.

[164] Council of Europe, Recommendation CM/Rec (2020)1 of the Committee of Ministers to member States on the human rights impacts of algorithmic systems (8 April 2020) preamble and paras 4-5.

traceability and human agency that, as aforementioned, is lacking in ADM.[165] As discussed in Section 4.2, algorithmic systems frequently operate through opaque processes, generate systemic rather than isolated errors, and redistribute decision-making across multiple actors.[166] In the maritime domain, where operational decisions are taken rapidly, often extraterritorially and through complex governance arrangements involving States, EU agencies and private actors, these features risk undermining the very conditions under which IHRL norms are meant to function.[167] The question, therefore, is not whether IHRL can formally extend to AI-based maritime surveillance, but whether its core requirements can be operationalised in environments characterised by automation and opacity.

In conclusion, the current chapter suggests that while IHRL is not structure-wise incapable of engaging with AI, its capacity to do so in the maritime context is subject to significant constraints. Its evolutive nature allows existing obligations to adapt, at least formally, to modern technologies. At the same time, as Alston has emphasised in the context of digital governance, the capacity of IHRL to operate effectively depends not only on doctrinal adaptability, but on institutional conditions that enable rights to be claimed and interpreted.[168] Where such conditions are weak or absent, the extension of human rights norms risks becoming largely symbolic rather than protective.[169] Therefore, the prospects for rights-compatible integration of AI under IHRL in the maritime domain remain conditional. While accommodation may be possible in theory, its meaningful realisation depends on structural features of governance that are frequently lacking in contemporary maritime border operations.

4.4. Conclusion

This chapter has examined the implications of AI-based maritime surveillance under IHRL, building on the technological, governance and legal analysis developed in Chapters 2 and 3. It first confirmed that IHRL applies to maritime contexts through territorial, flag-State and, crucially, effective-control jurisdiction, and that border surveillance based on AI may engage human-rights obligations, where it substantially influences how States assess and respond to individuals at sea. The chapter then analysed how the integration of AI may interfere with a range of human rights, including privacy and data protection, non-discrimination, the right to life and rescue, the prohibition of refoulement, and the right to an effective remedy. Although the individual rights examined are affected in different ways, the analysis shows common

[165] Maria O'Sullivan, 'Artificial Intelligence and the Right to an Effective Remedy' in Michał Balcerzak and Julia Kapelańska-Pręgowska (eds), 'Artificial Intelligence and International Human Rights Law' (Edward Elgar 2024) 200–203
[166] Council of Europe, (n 165).
[167] UN Special Rapporteur on the Human Rights of Migrants, 'Report on pushbacks and border governance', UN Doc A/HRC/ (2023) paras 23–31
[168] Philip Alston, 'Report of the Special Rapporteur on extreme poverty and human rights on digital technology, social protection and human rights', UN Doc A/74/48037 (11 October 2019) paras 8-12, 64-69.
[169] Ibid.

structural features of AI, such as opacity, systemic error, automation bias and fragmented responsibility, which complicate the practical application of human-rights standards at sea. Importantly, the chapter demonstrated that AI does not modify the substance of States' obligations under IHRL, but it does alter the modalities through which those obligations are implemented in practice.

Finally, it was examined whether IHRL is capable of accommodating the use of AI in the maritime domain. It showed that IHRL is constructed as a principle-based and evolutive framework. Its reliance on open-textured concepts, such as due diligence, proportionality, positive obligations and effective control, provides a degree of conceptual flexibility that allows human-rights norms to extend, at least formally, to AI-based practices. However, this conceptual adaptability does not automatically translate into effective protection. The capacity of IHRL to operate in AI-based contexts at sea depends on institutional and operational conditions, such as transparency and accountability, which are most of the times difficult to secure in practice. As a result, while AI does not fall outside the scope of IHRL, its rights-compatible implementation remains subject to practical constraints.

Chapter 5: Conclusions

This thesis examined how the use of AI in maritime surveillance systems affects the application of the LOS and IHRL. More specifically, it analysed the extent to which AI-based surveillance technologies influence the interpretation and application of legal obligations governing maritime activities as well as the protection of individuals at sea. By focusing on both legal regimes, the thesis sought to assess how existing frameworks respond to forms of monitoring, decision-making and control in the maritime domain based on AI.

From the perspective of the LOS, this thesis concluded that the integration of AI in maritime surveillance does not alter the normative framework established by UNCLOS and other related instruments. Obligations relating to navigation, flag State responsibilities and search and rescue remain legally intact and continue to apply in technologically advanced environments. At the same time, however, the analysis demonstrated that an exclusively UNCLOS-centred approach is insufficient to fully capture how contemporary maritime surveillance is governed in practice. The Convention's human-centred architecture and its reliance on treaty-based regulation limit its ability to address technologically mediated forms of monitoring and automated decision-making. As a result, the application of the Law of the Sea should depend more and more on interpretative practices and complementary regulatory activity within the broader UN system, particularly through institutions such as the IMO, which can adapt rapidly to evolving technological conditions without displacing the Convention's foundational role.

From an IHRL perspective, the thesis found that AI-based maritime surveillance has significant implications for how jurisdiction, due diligence and positive obligations are assessed and applied at sea. While the substantive content of human rights obligations remains unchanged, surveillance technologies based on AI transform the conditions under which those obligations are triggered in practice and introduce new risks linked to opacity and automation bias. As discussed in relation to the right to life, the use of AI systems may obscure how risk assessments are made and encourage excessive reliance on algorithmic outputs, potentially leading authorities to overlook conditions that legally amount to distress or to delay intervention. In such circumstances, the application of human rights obligations cannot be confined only to effective control through physical presence, but must also take into account a State's capacity to affect individuals' rights through surveillance-enabled decision-making in situations of known and foreseeable risk.

In sum, the findings of this thesis demonstrate that the use of artificial intelligence in maritime surveillance systems does not fall outside existing international legal frameworks, nor does it fundamentally alter the content of States' obligations under the Law of the Sea or international human rights law. Instead, AI reshapes the conditions, under which those obligations are applied in practice. By enhancing States' capacity to monitor maritime spaces, generate knowledge and take decisions at a distance, AI affects how concepts such as control, foreseeability, jurisdiction and due diligence are operationalized across both legal regimes. At

the same time, the reliance on AI-based systems introduces new challenges, which may undermine the effective protection of rights if not properly accounted for. The central challenge posed by AI-based maritime surveillance is therefore not one of legal absence, but of legal application. Further research should examine how established legal principles, developed in a human-centred and treaty-based context, can continue to be interpreted and implemented in a manner that preserves accountability and the effective protection of individuals at sea under technologically mediated conditions.

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