

AN INTRODUCTION TO THE INTERPLAY OF LAW AND TECHNOLOGY WITHIN THE MARITIME DOMAIN

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Introduction

As it always has, science and technology (“*technology*”) continue to revolutionise the maritime domain.¹ Its civilian as well as military spheres are affected in lasting ways by technological advancements such as autonomous shipping and weapons, artificial intelligence, blockchain, etc. At the same time, these technological developments do not occur in a legal vacuum. Law is increasingly invoked today to regulate present as well as future deployment (and development) of technology. Regulation aside, law also has a wider relationship with technology and technological advancement, and the interplay between them is complex.²

¹ “What are the Main Technological Innovations in the Maritime Industry for 2023?,” 24 March 2023, *Sinay Maritime Data Solution*, <https://sinay.ai/en/what-are-the-main-technological-innovation-in-the-maritime-industry-for-2023/>

See also: Ana Ruiz García De Los Ríos, “The Impact of Technologies in the Maritime Sector from a Ship Agent’s Vision,” July 2021, *Fonasba*, https://www.fonasba.com/wp-content/uploads/2021/08/Ana-Ruiz-Garcia-de-los-Rios-The-impact-of-technologies-in-the-Maritime-sector-2021_.pdf

See also: Tino Vidović et al, “Systematic Overview of Newly Available Technologies in the Green Maritime Sector,” *Energies* 16, no. 2: 641, <https://www.mdpi.com/1996-1073/16/2/641/pdf?version=1672912601>

See also: Evert A Bouman et al, “State-of-the-Art Technologies, Measures, and Potential for Reducing GHG Emissions from Shipping - A review,” *Transportation Research Part D* 52 (2017) 408-421, <https://www.sciencedirect.com/science/article/pii/S1361920916307015/pdf?md5=514a165c03613da235ff6cb9b3361e26&pid=1-s2.0-S1361920916307015-main.pdf>

See also: World Maritime University, *Transport 2040: Impact of Technology on Seafarers - The Future of Work*, 2023, https://commons.wmu.se/cgi/viewcontent.cgi?article=1091&context=lib_reports

² Jonathan B Wiener, “The Regulation of Technology, and the Technology of Regulation,” *Technology in Society* 26 (2004): 483-500, https://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1960&context=faculty_scholarship

See also: Wil C G Burns and Andrew L Strauss, eds., “Climate Change Geoengineering: Philosophical Perspectives, Legal Issues, and Governance Frameworks”, (Cambridge University Press, 2013).

See also: Alessandro Di Martino, “The Relationship between Law and Technique in the Construction of Administration by Algorithms,” *European Review of Digital Administration & Law - Erdal* 2, No 1 (2021): 199-215, <https://www.erdalreview.eu/free-download/979125994243215.pdf>

See also: Kadir Murat Altintas, “Comparative Analysis of Strategic Relationship between Industrial versus Corporate Espionage within the Framework of Implementation Methods,” *Global Security and Intelligence Studies* 6, No 1 (Spring / Summer 2021), <https://gsis.scholasticahq.com/article/25510-comparative-analysis-of-strategic-relationship-between-industrial-versus-corporate-espionage-within-the-framework-of-implementation-methods/attachment/64800.pdf>

See also: Katarina Radonjić, “The Nature of the Relationship between American Multinational Corporations and Chinese Businesses and its Effect on the Problem of Intellectual Property Law” (Master’s thesis, University of Ottawa, 2012), <https://ruor.uottawa.ca/server/api/core/bitstreams/078bdc10-e60f-4b70-bc29-81955ac9c9d2/content>

This article seeks to provide an introduction to this complexity as manifested in the maritime domain. A history of the relationship between law and technology is briefly explored, and the more significant of the influences of one upon the other are outlined. The contemporary interplay between the two is illuminated by highlighting legal issues raised by a few representative new ‘autonomous’ technologies and their use in civilian and military spheres. A fuller list of new maritime technologies and in-depth examination of legal issues raised thereby is intended for subsequent articles and is not provided in this introductory text.

Background

Some general propositions can be made on the interplay between law and technology.

First, technological advancement frequently necessitates legal action. This can be in the form of amendment of existing legal provision(s), or introduction of new provision(s), or both. The dynamics of this aspect have been characterised by Prof David D Friedman (Professor Emeritus at Santa Clara University’s School of Law) who observed that technological change and/or advancement can affect the law in “*at least*” three ways:

- By changing the cost of violations, or the cost of enforcement, or both.
- By changing underlying facts that justify legal rules.
- By altering underlying facts that are implicitly assumed by the law, such that existing legal categorisation and conceptualisation become obsolete or meaningless.³

History is full of instances where technological change affected — even necessitated — law and legal development. For instance, the introduction of railroads demanded the resolution of a slew of legal issues relating to property rights, liability for damages, etc. Likewise, the advent of computers necessitated legal clarity about the evidentiary value of computer printouts, the ability of computer storage to constitute legal writing (like for a will), the tangibility of computer software for purposes of taxation, etc.⁴ Similarly (and more aligned to the maritime domain), modern development of the law of the sea that occurred through the extensive provisions of the

See also: Charlotte Salpin and Valentina Germani, “Patenting of Research Results Related to Genetic Resources from Areas beyond National Jurisdiction: The Crossroads of the Law of the Sea and Intellectual Property Law” *Review of European Community & International Environmental Law* 16, No 1 (2007): 12-23.

See also: Aleksandar Milanov, “Management of Outer Space Economic Resources - Legal and Political Challenges,” *Conferencii* (1) 2 (2021).

See also: Henry H Perritt, Jr, “The Internet is Changing the Public International Legal System,” *Chicago-Kent College of Law*, http://www.kentlaw.edu/cyberlaw/perrittnetchg.html#_ftn1

See also: Karen Filbee-Dexter and Anna Smajdor, “Ethics of assisted evolution in marine conservation,” *Frontiers in Marine Science* 6 (2019): 20,

<https://www.frontiersin.org/articles/10.3389/fmars.2019.00020/pdf?isPublishedV2=False>

³ David D Friedman, “Does Technology require New Law?”, *Harvard Journal of Law & Public Policy* 25 (2001): 71, <https://core.ac.uk/download/pdf/149256227.pdf>

See also: Roger Brownsword et al, eds., *The Oxford Handbook of Law, Regulation and Technology* (Oxford University Press, 2017), 7-10.

See also: Daniel J Gifford, “Law and Technology: Interactions and Relationships,” *Minnesota Journal of Law, Science & Technology* 8 (2007): 571,

https://conservancy.umn.edu/bitstream/handle/11299/156335/ahc_asset_365982.pdf?sequence=1

⁴ Lyria Bennett Moses, “Recurring Dilemmas: The Law’s Race to Keep Up with Technological Change,” *University of Illinois Journal of Law, Technology and Policy* (2007): 1-2, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=979861

“United Nations Convention on The Law of The Sea”, addressed the factual technological gap between developed and developing States.⁵ Another example is offered by the technological advancements in resource-extraction, including in fishing, which led (as will be discussed below) to expanding maritime jurisdictional claim(s) by States.

Second, the law generally — if not invariably — lags behind technology, and the growth of international law is particularly glacial. There can be many reasons for this lag. Among other things, it has been attributed to “*the dichotomy between the cautious approach of lawyers and the “move fast and break things” mentality of technologists, whose work disrupts societies and norms at unprecedented speeds.*”⁶ Prof PW Singer, who served as a consultant for the US intelligence, military and law enforcement community (among other appointments in and outside government), observed:

“During World War I, for example, all sorts of new technologies, from airplanes dropping bombs to cannons shooting chemical weapons, were introduced before anyone agreed on the rules for their use. As to be expected, the warring sides sometimes took different interpretations.... This lack of legal clarity even helped induce America to join the war; the submarine attacks on merchant ships that the Germans saw as justifiable were instead viewed as war crimes on the other side of the Atlantic..... Chemical weapons were first introduced in World War I, but they weren’t fully banned until eighty-two years later.”⁷

Despite its slow pace, the law does respond to technological change. Advancements in technology have enabled — since at least the 11th century — ever growing abilities to exploit marine resources such as fish.⁸ This has, in turn, necessitated (or served as a justification for, depending on perspective) legal responses to address issues of overexploitation, the rights of coastal States, etc. Thus, in 1945, President Truman of the USA issued the Truman Proclamations, setting out US policy on the oceans and its resources. The press release accompanying these proclamations noted how they had been necessitated by technological advancement(s):

“The advance of technology prior to the present war had already made possible the exploitation of a limited amount of minerals from submerged lands within the 3-mile limit. The rapid development of technical knowledge and equipment occasioned by the war now makes possible the determination of the resources of the submerged lands outside of the 3-mile limit. With the need for the discovery of additional resources of petroleum and other minerals, it became advisable for the United States to make possible

⁵ Articles 143, 144, 148, 150, Part XIV, Annex III (Articles 5, 13, 17(xi)), *United Nations Convention on The Law of the Sea*, https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

See also: Dr Scott Parsons, “Transfer of Marine Technology,” IOC/ABE-LOS1/8, SC.2001/CONF.207/CLD.5, 27 April 2001, *International Oceanographic Commission (of UNESCO)*, <https://unesdoc.unesco.org/ark:/48223/pf0000122697>

See also: James Stavridis, “Marine Technology Transfer and the Law of the Sea,” *Naval War College Review*: Vol 36, No 4, Article 6 (1983), <https://digital-commons.usnwc.edu/cgi/viewcontent.cgi?article=4760&context=nwc-review>

⁶ Lindsay Freeman, “Law in Conflict: The Technological Transformation of War and its Consequences for The International Criminal Court,” *NYUJ Int’l L. & Pol.* 51 (2018): 811, <https://nyujilp.org/wp-content/uploads/2019/07/NYI303.pdf>

⁷ PW Singer, *Wired for War: Robotics revolution and Conflict in the 21st Century* (Penguin, 2009), 387-388.

⁸ Mary Ann Palma et al, *Promoting Sustainable Fisheries: The International Legal and Policy Framework to combat Illegal, Unreported and Unregulated Fishing* (Martinus Nijhoff Publishers, 2010), 1.

*orderly development of these resources. The proclamation of the President is designed to serve this purpose.”*⁹

In this instance, legal responses to technological change did not end with the proclamations. The proclamations, in turn, sparked a practical “movement” among other States to unilaterally expand their own maritime jurisdiction(s).¹⁰ In addition to the precedent set by the USA, the actions of other States were further catalysed by the inadequacy (real or perceived) of the prevailing legal regime to respond to new technologies and concomitant economic realities. In a book on the law and politics of ocean governance, the authors explained:

*“[M]ost regional fisheries organizations established during the old high seas regime proved inefficient. The freedom of the seas doctrine did not differentiate between the rights and duties of states to high seas fisheries resources, nor did it establish any sanctions for fishing nations that did not cooperate or abide by measures established under regional fishery regimes.... From the end of the Second World War onwards, a growing number of states came to regard the high seas regime as both inequitable and inefficient. Some coastal states reacted by making unilateral claims to jurisdiction over the waters beyond their territorial seas and the living marine resources there.... Agreement on the introduction of exclusive economic zones (EEZs) was reached at an early stage, and was widely acknowledged by the second half of the 1970s. The expectation was that EEZs would provide coastal states with the authority and incentives to conserve and manage the living marine resources in a sustainable manner.”*¹¹

Thus, a third general proposition can be distilled, namely, that technology has direct and indirect effects upon law. Consider fishing regulations as an example of direct effect. As the ability to exploit resources (including fish) increased, it was felt necessary to adapt the law to restrict fishing activity, prevent overexploitation, conserve rights of coastal States, etc. Algerian author M Dahmani observed thus on the legal regime for fishing and fisheries:

⁹ “Proclamation 2667 - Policy of the United States with respect to the Natural Resources of the Subsoil and Sea Bed of the Continental Shelf,” 28 September 1945, *The American Presidency Project*, <https://www.presidency.ucsb.edu/documents/proclamation-2667-policy-the-united-states-with-respect-the-natural-resources-the-subsoil>

See also: RP Anand, *Origin and Development of The Law of The Sea: History of International Law Revisited* (Martinus Nijhoff Publishers, 1983), 234.

¹⁰ Donald Cameron Watt, “First Steps in the Enclosure of the Oceans: The Origins of Truman’s Proclamation on the Resources of the Continental Shelf, 28 September 1945,” *Marine Policy* 3, No 3 (July): 211.

See also: Ann L Hollick, “The Origins of 200-Mile Offshore Zones,” *The American Journal of International Law* 71, No 3 (Jul 1977): 495.

See also: Francisco Orrego Vicuña, ed., *The Exclusive Economic Zone: A Latin American Perspective* (Routledge, 2019), 11, 13, 19.

See also: Gemma Andreone, “The Exclusive Economic Zone”, in *The Oxford Handbook of The Law of The Sea*, eds Donald Rothwell et al, (Oxford University Press, 2015), 3, 16.

See also: Charles Quince, *The Exclusive Economic Zone* (Vernon Press, 2019), 5, 10-11.

See also: S N Nandan, “The Exclusive Economic Zone: A Historical Perspective,” *The Food and Agriculture Organisation of the United Nations*, <https://www.fao.org/3/s5280T/s5280t0p.htm>

See also: M Dahmani, *The Fisheries Regime of The Exclusive Economic Zone* (Martinus Nijhoff Publishers, 1987), 14-15.

¹¹ Tore Henriksen et al, *Law and Politics in Ocean Governance: The UN Fish Stocks Agreement and Regional Fisheries Management Regimes* (Martinus Nijhoff Publishers, 2006), 3-4.

See also: Ann L Hollick, “The Origins of 200-Mile Offshore Zones,” 496.

“Insofar as the fishery resources of the sea were concerned, as long as those resources were believed to be inexhaustible, no form of regulation or restriction upon the freedom of the seas could be justified. Thus freedom of fishing, as one of the freedoms of the seas, meant that no nation could validly assert jurisdiction overfishing activities beyond the narrow limits of the territorial sea, whatever the circumstances might be... Freedom of fishing also meant there could be no limitation on the number of people or vessels, the fishing effort or amount of fish to be caught, whatever the circumstances might be... From the beginning of the 20th century [however], the need to adapt the traditional concept of the freedom of the seas, to the state of affairs created by the development of new techniques in the use and exploitation of the sea, became quite clear and pressing. It was only logical that this freedom should come under attack once its premises [of unlimited resources and unrestricted exploitation] were no longer valid.”¹²

On the other hand, when technological advancement alters the economics underpinning legal systems, it exercises indirect effect(s) upon law. In the case of expanding maritime jurisdictional claims by States (above), this phenomenon was characterised by Gilbert Apollis (Professor of International Law) as a “*transformation of economic sovereignty into political or territorial sovereignty*.”¹³

Of course, even while it is informed by technology, law simultaneously regulates (and incentivises) many areas of maritime technological advancement, such as engine design, emission control, biotechnology, artificial intelligence, cyberspace, etc.¹⁴

Having thus set the background, the subsequent section of this article outlines some facets of contemporary interplay between law and technology.

Contemporary Interplay

Modern maritime law is (largely) informed by evidence, and technology remains a powerful source of such evidence. It reveals in ever growing detail the maritime world — including its resources — to lawmakers, policymakers, and decision-makers. Its tools are harnessed as a fundamental part of informed decision-making and evidence-based policies. Modern technologies such as uncrewed underwater vehicles (UUVs), satellite imaging, remote sensing, etc., have transformed the collection and analysis of data. They inform (and sometimes

¹² M Dahmani, *The Fisheries Regime of The Exclusive Economic Zone*, 1-2.

See also: Charles Quince, *The Exclusive Economic Zone*, 8.

See also: Francisco Orrego Vicuña, ed, *The Exclusive Economic Zone: A Latin American Perspective*, 82.

¹³ Gilbert Apollis, *L'Emprise Maritime de l'Etat Côtier* (Paris: Pedone, 1981), as cited in Francisco Orrego Vicuña, ed., *The Exclusive Economic Zone: A Latin American Perspective*, 138.

¹⁴ Roger Brownsword et al, eds, *The Oxford Handbook of Law, Regulation and Technology*.

See also: Nicholas Davis et al, “The Anatomy of Technology Regulation,” 17 February 2022, *Brookings*, <https://www.brookings.edu/articles/the-anatomy-of-technology-regulation/>

See also: “Nitrogen Oxides (NOx) Regulations,” Daihatsu, <https://www.dhhd.co.jp/en/products/marine/nox.html>

See also: “Transformative technologies (AI) challenges and principles of regulation,” 8 September 2023, *Digital Regulation Platform*, <https://digitalregulation.org/3004297-2/>

See also: United Nations, *Compendium of International Arrangements on Transfer of Technology: Selected Instruments*, 2001, <https://unctad.org/system/files/official-document/psiteipcm5.en.pdf>

misinform) the making and enforcement of rules and policies on maritime matters such as security, biodiversity, pollution, etc.¹⁵

Consider fishing. Contemporary national and international law on fishing is informed in formulation — and assisted in enforcement — by technology-enabled collection and analysis of data. This was noted, for instance, in a 2017 Issue Paper by “The Organisation for Economic Cooperation and Development” (OECD):

“New information and monitoring technologies are potential game-changers for fisheries management and can be of help in achieving green growth of the sector. Application of new technologies has allowed governments to collect more data on fish stocks, better monitor, enforce and evaluate the environmental impacts of fisheries activities and improve the effectiveness of policies to sustainably manage fisheries. To this end, there are many recent technological developments [including] the increased computing power of handheld devices; the proliferation of user-friendly Global Positioning System (GPS) and Global Navigation Satellites Systems (GNSS) applications; increased capacity for “big data” storage, sharing, and analysis; variety and improved durability of drones and low-maintenance radar stations; accessibility and accuracy of satellite imagery; continuous improvements in on-board digital cameras and recorders; expanded use of Automatic Identification Systems (AIS) and Vessel Monitoring Systems (VMS), and the internet at sea.”¹⁶

¹⁵ Bhim S Kothari, “The Role of Technology in Maritime Security : A Survey of its Development, Application, and Adequacy” (Master’s dissertation, World Maritime University, 2008), 48-81, https://commons.wmu.se/cgi/viewcontent.cgi?article=1361&context=all_dissertations
See also: Hance D Smith, ed, *Advances in the science and technology of ocean management* (Routledge, 1992).
See also: Ripon Bhattacharjee and Bhupal Bhattacharya, “The Intersection of Technology and Environmental Law: Recent Developments and Future Challenges,” *Indian Journal of Law & Justice* 14, No 2 (2023): 199, https://ir.nbu.ac.in/bitstream/123456789/5069/1/Intersection%20of%20Technology%20and%20Environmental%20Law%20Recent%20Developments%20and%20Future%20Challenges_12.pdf
See also: Ifesinachi Okafor-Yarwood et al, “Technology and Maritime Security in Africa: Opportunities and Challenges in Gulf of Guinea,” *Marine Policy* 160 (February 2024), <https://doi.org/10.1016/j.marpol.2023.105976>
See also: John P Craven, “The Technology and the Law of the Sea: The Effect of Prediction and Misprediction,” *Louisiana Law Review* 45, No 6 (1984): 1143-1159, <https://digitalcommons.law.lsu.edu/cgi/viewcontent.cgi?article=4928&context=llrev>
See also: Mina Taddos et al, “Review of Current Regulations, Available Technologies, and Future Trends in the Green Shipping Industry,” *Ocean Engineering* 280 (2023): 114670, <https://doi.org/10.1016/j.oceaneng.2023.114670>
See also: Marilyn A Brown and Benjamin K Sovacool, eds, *Climate Change and Global Energy Security: Technology and Policy Options* (MIT Press, 2011).
See also: Rahul Sharma, ed, *Perspectives on Deep-Sea Mining: Sustainability, Technology, Environmental Policy and Management* (Springer, 2022).
See also: Muhammad Bilawal Khaskheli et al, “Technology Advancement and International Law in Marine Policy: Challenges, Solutions and Future Prospective,” *Frontiers in Marine Science* (October 2023): 3, <https://www.frontiersin.org/articles/10.3389/fmars.2023.1258924/full>
¹⁶ Pierre Girard and Thomas Du Payrat, *An Inventory of New Technologies in Fisheries* (The Organisation for Economic Cooperation and Development, 2017), https://www.oecd.org/greengrowth/GGSD_2017_Issue%20Paper_New%20technologies%20in%20Fisheries_WE_B.pdf
See also: “Impacts of Technological Change on Efficiency, Equity and Poverty in Small-Scale Fisheries”, *Food and Agriculture Organisation of the United Nations*, <https://www.fao.org/3/y3914e/y3914e0a.htm>
See also: John Fitzpatrick, “Technology and Fisheries Legislation,” *Food and Agriculture Organisation of the United Nations*, <https://www.fao.org/3/w1238e/W1238E09.htm>
See also: Jayme Garcia Arnal Barbedo, “A Review on the Use of Computer Vision and Artificial Intelligence for Fish Recognition, Monitoring, and Management,” *Fishes* 7, No 6 (2022), <https://doi.org/10.3390/fishes7060335>

In addition to informing law and policy, technology impacts existing frameworks by enabling communication and information-exchange between all kinds of actors (not just States), including in real time and beyond spatial boundaries. This facilitates transboundary collaboration and coordination and, is particularly helpful in addressing transboundary challenges such as climate change.¹⁷

This article now undertakes a short, contemporary case-study illustrating the manner in which emerging technologies can give rise to legal issues.

Autonomous technologies in ships, vessels, etc., are a rising phenomenon.¹⁸ However, legal uncertainties also arise in their wake. In December 2021, the Legal Committee of the International Maritime Organisation (IMO) published the results of a “*regulatory scoping exercise and gap analysis*” it undertook in the context of what it termed “maritime autonomous surface ships” (MASS). The exercise identified the following as “*the main potential common gaps and/or themes*” which require clarity in the context of MASS:¹⁹

¹⁷ Michael Burger et al, “The Law and Science of Climate Change Attribution,” *Columbia Journal of Environmental Law* 45, No 1 (2020), <https://doi.org/10.7916/cjel.v45i1.4730>

See also: United Nations, Intergovernmental Panel on Climate Change (Working Group III), *Climate Change 2022: Mitigation of Climate Change*, 2022, 1644-1701,

https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf

See also: Yogesh K Dwivedi et al, “Climate change and COP26: Are Digital Technologies and Information Management Part of the Problem or the Solution? An Editorial Reflection and Call to Action,” *International Journal of Information Management* 63 (2022): 102456, <https://doi.org/10.1016/j.ijinfomgt.2021.102456>

See also: International Telecommunication Union, *Frontier technologies to protect the environment and tackle climate change*, April 2020, <https://www.itu.int/en/action/environment-and-climate-change/Documents/frontier-technologies-to-protect-the-environment-and-tackle-climate-change.pdf>

See also: International Telecommunication Union, *United Nations Activities on Artificial Intelligence*, 2022, https://www.itu.int/dms_pub/itu-s/opb/gen/S-GEN-UNACT-2022-PDF-E.pdf

See also: R G Breeze, “Technology, Public Policy and Control of Transboundary Livestock Diseases in our Lifetime,” *Revue Scientifique et Technique — Office International des Épidémiologies* 25, No 1 (2006): 271, http://www.pathobiologics.org/ivphc/ref/Breeze_FinalOIEpaper.pdf

See also: Imad Antoine Ibrahim, “Legal implications of the use of big data in the transboundary water context,” *Water resources management* 34, No 3 (2020): 1139-1153.

¹⁸ “Autonomous Ships,” *International Lashing Systems*, <https://www.ils.be/autonomous-ships/>

See also: Rory Cross, “Navigating the future: the promise of autonomous boats,” 24 March 2023, *UNSW Sydney*, <https://www.unsw.edu.au/newsroom/news/2023/03/navigating-the-future--the-promise-of-autonomous-boats>

See also: Naida Hakirevic Prevljak, “Hyundai Mipo Completes South Korea’s first autonomous vessel,” 11 March 2024, *Offshore Energy*, <https://www.offshore-energy.biz/hyundai-mipo-completes-south-koreas-first-autonomous-vessel/>

See also: Anastasiya Azarko, “The rising tide of the autonomous ships market,” 29 November 2023, *Open Access Government*, <https://www.openaccessgovernment.org/article/the-rising-tide-of-the-autonomous-ships-market/170749/>

¹⁹ Legal Committee (International Maritime Organisation), *Outcome of the regulatory scoping exercise and gap analysis of conventions emanating from the legal committee with respect to maritime autonomous surface ships (MASS)*, LEG.1/Circ.11, 15 December 2021, 6, [https://www.wcdn.imo.org/localresources/en/MediaCentre/HotTopics/Documents/LEG.1-Circ.11%20-%20Outcome%20Of%20The%20Regulatory%20Scoping%20Exercise%20And%20Gap%20Analysis%20Of%20Conventions%20Emanating%20From...%20\(Secretariat\).pdf](https://www.wcdn.imo.org/localresources/en/MediaCentre/HotTopics/Documents/LEG.1-Circ.11%20-%20Outcome%20Of%20The%20Regulatory%20Scoping%20Exercise%20And%20Gap%20Analysis%20Of%20Conventions%20Emanating%20From...%20(Secretariat).pdf)

See also: Alexandros X M Ntovas, “Functionalism and Maritime Autonomous Surface Ships,” in *Emerging Technology and the Law of the Sea*, eds James Kraska and Young-Kil Park, (Cambridge University Press, July 2022), 214-240.

See also: European Commission, *Maritime Unmanned Navigation through Intelligence in Networks*, D9.3: Quantitative Assessment, 12 October 2015, 57-135, <http://www.unmanned-ship.org/munin/wp-content/uploads/2015/10/MUNIN-D9-3-Quantitative-assessment-CML-final.pdf>

(a) **The Role and Responsibility of the Master.** The IMO noted the ambiguity of the terms ‘master’, ‘crew’, and ‘responsible person’ in the context of MASS, and the difficulty of apportioning liability in the absence of clear definitions.²⁰ It observed the need to “*clarify who, if anybody, would have to satisfy the role of the master in the case of a MASS with no master on board; if an owner (or charterer) would have additional duties or liabilities when operating a semi-autonomous or fully autonomous vessel; or if certain responsibilities that would normally belong to the master would transfer to those actually on board a vessel in cases of semi-autonomous vessels with limited crews; or could be carried out by personnel not on board the MASS.*”²¹ Indeed, a common conclusion arrived at by two committees of the IMO, namely, the Legal Committee, and the Maritime Safety Committee, was that the role and responsibilities of the master (and remote operator, considered below) were “*high priority issues [that] must be addressed as a foundation for any further work.*”²²

(b) **The Role and Responsibility of the Remote Operator.** Noting the emergence of remote operators of ships as new actors in fact and in law, the IMO observed that “*it may be necessary to clarify the role and responsibility of the remote operator.*”²³ It noted, in particular, the need to clarify “*whether the remote operator might fall within the scope of the terms, including but not limited to, “operator” or “servant or agent”, which are used within the liability and compensation regime, in order for the liability, channelling and subrogation provisions in those conventions to clearly accommodate MASS.*”²⁴ Others have pointed out that even the qualifications required to legally operate a MASS are neither currently clear nor uniform.²⁵

(c) **Questions of Contractual and Tortious Liability.** When MASS go wrong, should it be considered a human fault or technical failure? It is unclear if or how existing legal regimes for liability and compensation can be applied to MASS. This was highlighted by the IMO, which noted that there is little clarity on how or whether the new actors introduced by MASS — like remote operators, remote control centres/stations, providers of network or computer systems, and system developers — will be covered by existing legal frameworks. It emphasised, in particular, the necessity to consider “*whether the current list of exonerations, the provisions on channelling of liability and the provisions regarding subrogation are sufficient.*”²⁶

See also: Henrik Ringbom, Erik Røsæg, and Trond Solvang, eds., *Autonomous Ships and the Law* (New York: Routledge, 2021).

See also: Anna Petrig, “Unconventional Law for Unconventional Ships? The Role of Informal Law in the International Maritime Organisation’s Quest to Regulate Maritime Autonomous Surface Ships,” in *Unconventional Lawmaking in the Law of the Sea*, ed. Natalie Klein (Oxford University Press, 2022).

²⁰ Legal Committee (International Maritime Organisation), *Outcome of the regulatory scoping exercise and gap analysis*, 8-10.

²¹ *Ibid.*, 6.

²² *Ibid.*, 9-10.

²³ *Ibid.*, 7.

²⁴ *Ibid.*

²⁵ European Commission, *Maritime Unmanned Navigation through Intelligence in Networks*, 84.

See also: Junghwan Choi & Sangil Lee, “Legal Status of the Remote Operator in Maritime Autonomous Surface Ships (MASS) Under Maritime Law,” *Ocean Development & International Law*, 52:4: 451, 455.

²⁶ Legal Committee (International Maritime Organisation), *Outcome of the regulatory scoping exercise and gap analysis*, para 5.5, 7.

(d) **Definitions/Terminology of MASS.** The Legal Committee emphasised the importance of terminology in the context of MASS and stressed that it needed to be “revisited.”²⁷ It noted that agreement on terminology would be needed, for instance, to consider amendments to legal instruments or develop new legal instruments.²⁸ In particular, it identified for examination concepts of ‘fault’, ‘negligence’, and ‘intention’ in the context of MASS.²⁹

(e) **Insurance Certificates.** These are required, by international liability conventions (such as the International Convention on Civil Liability for Oil Pollution Damage, 1992, for example) to be carried or kept on board a ship. The IMO wondered how the insurance certificate for a MASS — without any seafarers on board — could or would be accessed for purposes of Port State Control.³⁰

Autonomous technologies have legal as well as safety implications. Thus, in addition to the aforementioned issues identified by the Legal Committee, “*potential gaps*” were also pointed out in a similar scoping exercise conducted by the IMO’s Maritime Safety Committee. These are tabulated in **Table 1**.³¹

	Common Potential Gaps and/or Themes	Instruments where Potential Gaps were Identified
1	Meaning of the terms “master”, “crew”, or “responsible person”.	<ul style="list-style-type: none"> • International Convention for the Safety of Life at Sea (SOLAS), 1974: chapters II-2, III, V, VI, VII IX and XI-1. • Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972. • International Convention on Tonnage Measurement of Ships, 1969. • International Convention on Load Lines, 1966 (LL Convention) and its 1988 Protocol. • Intact Stability Code. • IMO Instruments Implementation Code (III Code).

See also: T K Lee, “Liability of Autonomous Ship: The Scandinavian Perspective” (Master’s thesis, University of Oslo, 2016),

https://www.duo.uio.no/bitstream/handle/10852/54101/MasterThesis_8018.pdf?sequence=1&isAllowed=y

²⁷ Legal Committee (International Maritime Organisation), *Outcome of the regulatory scoping exercise and gap analysis*, para 6.3, 10.

²⁸ *Ibid*, para 5.13, 9.

²⁹ *Ibid*, para 6.3, 10.

See also: Luci Carey, “Contractual and Tortious Maritime Liability Regimes and the Introduction of Autonomous Vessels” (March 2023), NUS Centre for Maritime Law Working Paper 23/03, <https://law.nus.edu.sg/wp-content/uploads/2023/03/CML-WPS-2303.pdf>

See also: Yavar Bathaee, “The Artificial Intelligence Black Box and the Failure of Intent and Causation,” *Harv. JL & Tech.* 31 (2017): 889, <https://jolt.law.harvard.edu/assets/articlePDFs/v31/The-Artificial-Intelligence-Black-Box-and-the-Failure-of-Intent-and-Causation-Yavar-Bathaee.pdf>

³⁰ Legal Committee (International Maritime Organisation), *Outcome of the regulatory scoping exercise and gap analysis*, para 5.7, 7.

³¹ Maritime Safety Committee (International Maritime Organisation), *Outcome of the Regulatory Scoping Exercise for the use of Maritime Autonomous Surface Ships*, MSC.1/Circ.1638, 3 June 2021, 7, [https://wwwcdn.imo.org/localresources/en/MediaCentre/PressBriefings/Documents/MS-C.1-Circ.1638%20-%20Outcome%20Of%20The%20Regulatory%20Scoping%20ExerciseFor%20The%20Use%20Of%20Maritime%20Autonomous%20Surface%20Ships...%20\(Secretariat\).pdf](https://wwwcdn.imo.org/localresources/en/MediaCentre/PressBriefings/Documents/MS-C.1-Circ.1638%20-%20Outcome%20Of%20The%20Regulatory%20Scoping%20ExerciseFor%20The%20Use%20Of%20Maritime%20Autonomous%20Surface%20Ships...%20(Secretariat).pdf)

		<ul style="list-style-type: none"> • International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW Convention); and Seafarers' Training, Certification and Watchkeeping (STCW) Code.
2	Remote Control Station/Centre	<ul style="list-style-type: none"> • SOLAS chapters II-1, II-2, III, IV, V IX and XI-1. • International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW Convention); and Seafarers' Training, Certification and Watchkeeping (STCW) Code. • FSS. International Code for Fire Safety Systems (FSS Code). • International Safety Management (ISM) Code. • International Convention on Load Lines, 1966 (LL Convention) and its 1988 Protocol. • Casualty Investigation Code.
3	Remote Operator as a Seafarer	<ul style="list-style-type: none"> • SOLAS: Chapter IX. • International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW Convention). • International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995. • International Safety Management (ISM) Code.
4	Provisions containing manual operations, alarms to the bridge.	<ul style="list-style-type: none"> • SOLAS chapters II-1, II-2, VI and IX. • International Convention on Load Lines, 1966 (LL Convention) and its 1988 Protocol. • Intact Stability Code. • IMO Instruments Implementation Code (IIC Code).
5	Provisions requiring actions by personnel. (Examples included but are not limited to fire, spillage, cargo-management, onboard maintenance, etc.)	<ul style="list-style-type: none"> • SOLAS: Chapters II-2, VI, VII, IX and XII.
6	Certificates and Manuals on board.	<ul style="list-style-type: none"> • SOLAS chapters III, XI-1, XI-2 and XIV.
7	Connectivity, Cybersecurity	<ul style="list-style-type: none"> • SOLAS chapters IV, V and IX.
8	Watchkeeping	<ul style="list-style-type: none"> • SOLAS chapters IV and V. • COLREG.
9	Implications of MASS in Search and Rescue (SAR).	<ul style="list-style-type: none"> • SOLAS: Chapters III, IV and V. • Search and Rescue (SAR) Convention
10	Information to be available on board and required for the safe operation.	<ul style="list-style-type: none"> • SOLAS: Chapters II-1 and II-2.

11	Terminology	<ul style="list-style-type: none"> • SOLAS: Chapters II-1, IV and V. • COLREG • International Code for Fire Safety Systems (FSS Code). • International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk (IBC Code). • International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). • International Code for the Safe Carriage of Grain in Bulk (International Grain Code). • International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on board Ships (INF Code). • International Convention on Load Lines, 1966 (LL Convention) and its 1988 Protocol. • Intact Stability Code. • Search and Rescue (SAR) Convention. • International Convention on Tonnage Measurement of Ships, 1969. • Code of Safe Practice for Cargo Stowage and Securing (CSS Code). • Casualty Investigation Code.
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Table 1: List of potential gaps found by the IMO's Maritime Safety Committee, in Instruments under its purview

It is evident that a wide range of legal issues are thrown up by the advent of autonomous technologies. Legal clarity is similarly also required due to the increasing use of other technologies – like blockchain, artificial intelligence, encryption, etc., - in the maritime domain.³²

³² Marek Dubovec, "The Problems and Possibilities for using Electronic Bills of Lading as Collateral," *Arizona Journal of International & Comparative Law* 23, No 2 (2006): 437-466, <https://ssrn.com/abstract=2135246>
See also: Barış Soyer and Andrew Tettenborn, eds., *New Technologies, Artificial Intelligence and Shipping Law in the 21st Century* (Informa Law from Routledge, 2020).
See also: Linlin Chen, "Maritime rights, obligations, and liabilities of intelligent ships from the perspective of risk distribution," *Journal of International Maritime Safety, Environmental Affairs, and Shipping* 7, No 4 (2023): 1-13, <https://doi.org/10.1080/25725084.2023.2264566>
See also: Jyri Rajamäki et al, "The Ethics of Open Source Intelligence Applied by Maritime law Enforcement Authorities," in Audun Josang, ed., *Proceedings of the 17th European Conference on Cyber Warfare and Security ECCWS 2018*, 28-29 June 2018, Oslo, Norway, https://www.theseus.fi/bitstream/handle/10024/152174/Rajamaki_Sarlio-Siintola_Simola.pdf?sequence=1
See also: Emily M. Weitzenböck, "Legal Issues of Maritime Virtual Organisations," *Complex Series* 1, No 4 (2001), <https://www.jus.uio.no/ifp/forskning/om/publikasjoner/complex/2000-2005/complex-2001-04.pdf>
See also: Klemens Katterbauer, "Shipping of the Future: Cybersecurity Aspects for Autonomous AI-driven Ships," *Australian and New Zealand Maritime Law Journal* 36, No 1 (2022), <https://maritime.law.uq.edu.au/index.php/anzmlj/article/download/1434/2099>
See also: Gbenga Oduntan, *Sovereignty and Jurisdiction in the Airspace and Outer Space: Legal Criteria for Spatial Delimitation* (Routledge, 2012).
See also: Vera Alexandropoulou et al, "Maritime remote inspection technology in hull survey & inspection: A synopsis of liability issues from a European Union context," *Journal of International Maritime Safety, Environmental Affairs, and Shipping* 5, No 4 (2021): 184-195, <https://www.tandfonline.com/doi/pdf/10.1080/25725084.2021.2006463>
See also: Charlotte Salpin and Valentina Germani "Patenting of Research Results Related to Genetic Resources from Areas beyond National Jurisdiction: The Crossroads of the Law of the Sea and Intellectual Property Law," *Review of European Community & International Environmental Law* 16, No 1 (2007): 12-23.
See also: Catharine Banet, ed., *The Law of the Seabed: Access, Uses and Protection of Seabed Resources* (Brill Nijhoff, 2020).
See also: Natalie Klein, "Assessing Australia's Push Back to the Boats Policy under International Law: Legality and Accountability for Maritime Interceptions of Irregular Migrants," *Melbourne Journal of International Law* 15, No 2 (2014): 414, <https://classic.austlii.edu.au/au/journals/MelbJIL/2014/14.html>

Conclusion

As epistemic methods, law and science play their own roles in human existence and societal development. As such, the interplay between the two (including in the maritime domain) is rich, complex, and multi-layered.³³ The relationships between maritime law and technology, including the legal issues thrown up by emerging technologies in the maritime domain, remain particularly significant for governments as well as civil society.

This article has provided an introduction to this thematic area. As an introduction, it has not attempted to provide an exhaustive list of new maritime technologies or conduct an in-depth examination of all legal issues raised in their wake. Further research on the complex interplay between law and technology in the maritime domain is needed, and this remains a topic of ongoing research at the National Maritime Foundation. Accordingly, subsequent articles will consider individual technologies and associated legal issues and, conduct in-depth examination(s) of legal and technological interplay in each context.

About the Author

Mr Mayank Mishra is an Associate Fellow within the Public International Maritime Law (PIML) Cluster of the National Maritime Foundation (NMF). While his research essentially focuses upon the vitally important intersection of maritime law with maritime 'hard security' policy, he is also keenly interested in the equally critical and fascinating interplay between PIML and technology, especially where relevant to the maritime domain. The views expressed are those of the author, who can be reached at law9.nmf@gmail.com

See also: Surya P Subedi, ed., *Unilateral Sanctions in International Law* (Hart, 2021), 255-325.

See also: Michael N Schmitt and David S Goddard, "International Law and the Military Use of Unmanned Maritime Systems," *International Review of the Red Cross* 98 No 2 (2016): 567-592, https://international-review.icrc.org/sites/default/files/irc98_10.pdf

See also: Simon McKenzie, "Autonomous Technology and Dynamic Obligations: Uncrewed Maritime Vehicles and the Regulation of Maritime Military Surveillance in the Exclusive Economic Zone," *Asian Journal of International Law* 11, No 1 (2021): 146-175.

See also: James Kraska and Raul Pedrozo, eds, *Disruptive Technology and the Law of Naval Warfare* (Oxford, 2022).

See also: Ricky J Lee, *Law and Regulation of Commercial Mining of Minerals in Outer Space*, Vol 7 (Springer Science & Business Media, 2012).

³³ Anne Orford, "Scientific reason and the discipline of international law," *European Journal of International Law* 25, No 2 (2014): 369-385.

See also: Frederic R Kellogg, "Legal Fallibilism: Law (like Science) as a Form of Community Inquiry," *Discipline Filosofiche* 19, No 2 (2009), <https://ssrn.com/abstract=1484623>

See also: F S C Northrop, "The Epistemology of Legal Judgments," *Northwestern University Law Review* 58 (1963): 732, <https://core.ac.uk/reader/72834120>