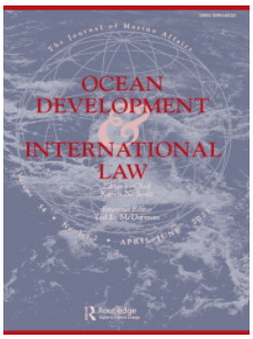

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Exploring the Autonomy-Neutral Character of the Existing Regulations

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Can the International Regulatory Framework on Ships' Routing, Ship Reporting, and Vessel Traffic Service (VTS) Accommodate Marine Autonomous Surface Ships (MASS)?

Exploring the Autonomy-Neutral Character of the Existing Regulations

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ABSTRACT

The recent maiden voyage of the *Yara Birkeland* witnessed yet another development in autonomy that is transforming the maritime sector. Marine autonomous surface ships (MASS) are claimed to bring many opportunities to society at large, not least in terms of operational efficiency and safety of the crew, fewer emissions, and greener shipping. On the assumption that MASS will prove safe enough to ply our seas and oceans, this article investigates the flexibility and ability of the existing International Maritime Organization (IMO) regulations on ships' routing, ship reporting, and vessel traffic service (VTS) to respond to the technological developments, allowing for the operation of both remotely controlled ships without seafarers on board and fully autonomous ships. It argues that the regulations in question are largely supportive of autonomy. Challenges, however, exist when it comes to the employment of fully autonomous ships and the effective use of VTS.

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Introduction

On 18 November 2021, the *Yara Birkeland* completed its maiden voyage from Horten to Oslo.[1] As often displayed in media, this electric containership is expected to cut 1,000 tonnes of CO_2 emissions and replace 40,000 trips that would otherwise be performed by diesel-powered trucks.[2] Although the *Yara Birkeland* is to operate in a solely domestic environment, the idea of marine autonomous surface ships (MASS) crossing

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[1] Yara International, "Yara to Start Operating the World's First Fully Emission-Free Container Ship" 19 November 2021, *Yara International* at: https://www.yara.com/corporate-releases/yara-to-start-operating-the-worlds-first-fully-emission-free-container-ship (accessed 6 November 2022). *Yara Birkeland* is currently operated with a manned bridge, with the idea to progressively transform into a fully unmanned ship.

[2] Owing to the expected reduction of NO_x and CO_2 emissions, the Norwegian government has subsidized the *Yara Birkeland* project. See Norwegian Government, *Action Plan* (2019), available at: https://www.regjeringen.no/cont

our seas and oceans on a global scale has been generating attention in the last couple of decades owing to significant technological developments and digitalization in the transportation sector.[3] The idea of MASS is surely ambitious and evolutionary, if not revolutionary.[4] Along with the benefits associated with operational efficiency,[5] MASS promise to bring many values to society at large, not least to support the recent trends in decarbonization and green shipping.[6] Safety of the crew is another key advantage.[7] However, challenges persist notwithstanding. Apart from the fact that the risk of technical failure is a constant concern, the coexistence of and interactions between MASS and conventional ships is another (novel) challenge that must be thoroughly considered.[8]

To gain a better understanding of MASS-related risks, states are opening testbeds in their waters[9] guided by the idea that MASS must be "at least as safe as" conventional ships. This is clearly spelled out in the interim guidelines that have already been adopted at the International Maritime Organization (IMO) (IMO Interim Guidelines),[10] illustrating, together with the IMO's regulatory scoping exercise,[11] the

entassets/2ccd2f4e14d44bc88c93ac4effe78b2f/the-governments-action-plan-for-green-shipping.pdf (accessed 3 April 2023).

[3] UNCTAD, *Review of Maritime Transport* (2020), 117, available at: https://unctad.org/publication/review-maritime-transport-2020 (accessed 3 April 2023). At present, however, full autonomy is mostly related to short coastal voyages. See The Swedish Club, *Triton No 2* (2021), 18, available at: https://www.swedishclub.com/media_upload/files/Publications/Triton/Triton22021v.13Finalreviewed.pdf (accessed 3 April 2023).

[4] Eric Van Hooydonk, "The Law of Unmanned Merchant Shipping—An Exploration" (2014) 20 *Journal of International Maritime Law* 403, 423.

[5] GARD, *Sustainability Report* (2019), 24, available at: http://www.gard.no/Content/29875294/GARD_sustainability_report_2019_low.pdf (accessed 3 April 2023); European Maritime Safety Agency (EMSA) and European Environment Agency, *European Maritime Transport Environmental Report* (2021), available at: https://www.eea.europa.eu/publications/maritime-transport (accessed 3 April 2023).

[6] Under the umbrella of the "European Green Deal," the European Union (EU) is advocating a very ambitious strategy of "zero emissions" and "zero pollution" and in this respect promotes the increased use of digitalization, automation, and new technology to contribute to sustainable maritime transport. See European Commission, *The EU Blue Economy Report* (2021), 62; European Commission, *A Clean Planet for All, A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy*, COM (2018) 773 final of 28 November 2018, 12. See also World Maritime University (WMU), *Transport 2040: Autonomous Ships: A New Paradigm for Norwegian Shipping—Technology and Transformation* (2019) 59 *WMU Reports* 1, 15; UNCTAD, *Review of Maritime Transport* (2019), 83; Ziaul Haque Munim, Rana Saha, Halvor Schøyen et al., "Autonomous Ships for Container Shipping in the Arctic Routes" (2021) 27 *Journal of Marine Science and Technology* 320, 326; RAMBOLL & CORE, "Analysis of Regulatory Barriers to the Use of Autonomous Ships: Final Report," 29, available at: https://dma.dk/Media/637745499808186153/Analysis%20of%20Regulatory%20Barriers%20to%20the%20Use%20of%20Autonomous%20Ships.pdf (accessed 6 November 2022).

[7] Here safety of crew relates to the fact that crew is not physically present on board MASS.

[8] See, e.g., Glenn Wright, *Unmanned and Autonomous Ships: An Overview of MASS* (Routledge, 2020), 118; Thomas Porathe, "Maritime Autonomous Surface Ships (MASS) and the COLREGS: Do We Need Quantified Rules or Is 'the Ordinary Practice of Seaman' Specific Enough?" (2019) 13 *International Journal on Marine Navigation and Safety of Sea Transportation* 511. As reported by industry, the challenge with human–machine interaction should not be underestimated. See The Swedish Club, note 3, 16. See also Jinho Yoo, Floris Goerlandt, and Aldo Chircop, "Unmanned Remotely Operated Search and Rescue Ships in the Canadian Arctic: Exploring the Opportunities, Risk Dimensions and Governance Implications" in Aldo Chircop, Floris Goerlandt, Claudio Aporta et al. (eds), *Governance of Arctic Shipping* (Springer, 2020) 98.

[9] For example, Trondheimsfjord in Northern Norway. See Safety4Sea, "First Official Test Bed for Autonomous Ships" 20 June 2017, Safety4Sea available at: https://safety4sea.com/first-official-test-bed-for-autonomous-ships (accessed 3 April 2023). The opening of the testbeds could implicate a rather privileged situation where the increase of knowledge and manufacturers in certain States will come at the exclusion of other users. An observation has been made that data will become the oil of the global economy. See WMU, *Transport 2040*, note 6, 24–25.

[10] IMO Doc. MSC.1/Circ.1064, 14 June 2019, Annex, 2, para. 2, *Interim Guidelines for MASS Trials*.

[11] For the IMO regulatory scoping exercise, see IMO Doc. MSC 98/23, 28 June 2017; LEG 105/14, 1 May 2018; LEG.1/Circ.11, 15 December 2021.

IMO's ambition to legalize MASS.[12] If MASS find a way to safely ply our oceans (which is naturally also related to the issue of public acceptance),[13] MASS will not operate within a regulatory vacuum. Legal scholarship has already begun to engage in the topic of MASS, but to what extent the current international regulatory framework is ready for autonomy is not entirely clear. One recuring theme among scholars is the ambiguity around the extent to which technological developments may be brought under the umbrella of the 1982 United Nations Convention on the Law of the Sea (UNCLOS)[14] to maintain the living character of the Convention, and the question of the legality of MASS within international maritime law.[15] Discussions are also present with respect to more specific scenarios such as search and rescue operations in the Canadian part of the Arctic.[16] However, the context of ships' routing, ship reporting, and vessel traffic service (VTS) has not been given much attention in the context of MASS.

This article attempts to fill this void to contribute to further understanding of the legal aptness, or the lack thereof, to autonomy. In its analysis, this article focuses on the third and fourth degrees of autonomy as defined at the IMO, that is, remotely controlled ships *without seafarers onboard* and fully autonomous ships, respectively.[17] The aim of this article is to reveal the flexibility and ability of the existing IMO regulations on safety measures—ships' routing, ship reporting, and VTS—to respond to the technological developments that allow for the operation of autonomous ships. As these regulations rely on the mandate of the IMO under the UNCLOS,[18] this article naturally starts with general discussions already present in law of the sea scholarship to synthesize the main issues, conclusions, and observations concerning the compatibility of MASS with UNCLOS. This author then offers their own understanding of these, while placing ships' routing, reporting, and VTS into perspective.

[12] Henrik Ringbom, "Legalizing Autonomous Ships" (2020) 34 *Ocean Yearbook* 431, 440.

[13] On the market, the question seems to be "when" rather than "if." Sean T. Pribyl, "Regulating Drones in Maritime and Energy Sectors" in Kimon P. Valavanis and George J. Vachtsevanos (eds), *Handbook of Unmanned Aerial Vehicles* (Springer, 2018), 21.

[14] United Nations Convention on the Law of the Sea, adopted 10 December 1982, entered into force 16 November 1994 1833 UNTS 3 (UNCLOS).

[15] Ringbom, note 12, 431; Henrik Ringbom, "Regulating Autonomous Ships—Concepts, Challenges and Precedents" (2019) 50 *Ocean Development & International Law* 141; Robert Veal, Michael Tsimplis, and Andrew Serdy, "The Legal Status and Operation of Unmanned Maritime Vehicles" (2019) 50 *Ocean Development and Coastal Law* 23, 39; Van Hooydonk, note 4, 403; Aldo Chircop, "Testing International Legal Regimes: The Advent of Automated Commercial Vessels" (2008) *German Yearbook of International Law* 1, 26. See also Joel Coito, "Maritime Autonomous Surface Ships: New Possibilities—and Challenges—in Ocean Law and Policy" (2021) 97 *International Law Studies* 260.

[16] Yoo, Goerlandt, and Chircop, note 8.

[17] At present, the IMO identifies four degrees of autonomy, notably (i) ships with *automated* processes and decision support, (ii) remotely controlled ships *with* seafarers on board, (iii) remotely controlled ships *without* seafarers on board, and (iv) fully *autonomous* ships. See IMO Doc. MSC 99/WP.9, 23 May 2018, Annex 1, 1 (endorsed by the MSC during its 100th session, MSC 100/20, 9, 10 January 2019). This particular definition of degrees of autonomy has been subject to criticism, largely because there is a gray area in between which does not appear fully appreciated. The issue has been extensively discussed and explained in Ringbom, note 15, 146.

[18] Although the IMO's mandate originates from the Convention on the International Maritime Organization (IMO Convention), in the contemporary and broader context the IMO's mandate is generally observed not only through the IMO Convention, but also through UNCLOS and some international maritime conventions (e.g., regarding *tacit acceptance*). See Aldo Chircop, "The IMO, Its Role Under UNCLOS and Its Polar Shipping Regulation" in Robert C. Beckman, Tore Henriksen, Kristine Dalaker Kraabel et al. (eds), *Governance of Arctic Shipping* (Brill, 2017), 109. The focus of this article is on UNCLOS.

The Compatibility of MASS With the 1982 United Nations Convention on the Law of the Sea (UNCLOS)

General Observations

UNCLOS is commonly known to be neither a completed nor a fixed instrument.[19] To accommodate modern trends and needs, UNCLOS has been opened to developments through subsequent state practice.[20] When it comes to shipping, such practice has mostly occurred through treaty interpretations and the already existing "in-built" mechanisms of "rules of reference,"[21] combined with Articles 237 and 311 of UNCLOS. Indeed, the IMO regulations are frequently referred to in UNCLOS as "generally accepted international rules and standards" (GAIRS). Borrowing from Ringbom, through such concepts as GAIRS, UNCLOS essentially avoids "freezing" shipping regulations at a certain technological level.[22] Yet, regardless of the fact that accommodating technological developments through IMO regulations and mechanisms such as GAIRS is indeed quite common,[23] UNCLOS was drafted and adopted on the assumption that ships are inherently navigated by humans. The idea of MASS thus raises some critical questions as to whether such autonomous ships are consistent with UNCLOS altogether, whether modifications to UNCLOS are required to govern MASS, and whether MASS may be considered ships in the first place.

Some scholars indicate that MASS do not easily qualify as ships under UNCLOS.[24] If that is the correct interpretation, the relevance of UNCLOS to the operation of MASS would be insignificant. In its preamble, UNCLOS makes it clear that matters not regulated under UNCLOS remain regulated under general international law.[25] While state practice regarding MASS has not developed yet, there is nothing to prevent such practice evolving, although it could be time-consuming. However, if the purpose of MASS is the same as that of ships, that is, to navigate seas and oceans, this author is not convinced that MASS should be treated any differently from traditional ships, specifically from the law of the sea perspective. In matters concerning shipping, UNCLOS is not concerned with ships per se, but with international navigation, and

[19] See Henrik Ringbom, "Introduction" in Henrik Ringbom (ed), *Jurisdiction over Ships, Post-UNCLOS Developments in the Law of the Sea* (Brill Nijhoff, 2015), 1.

[20] Irina Buga, "Between Stability and Change in the Law of the Sea Convention: Subsequent Practice, Treaty Modification, and Regime Interaction" in Donald Rothwell, Alex Oude Elferink, Karen Scott et al. (eds), *The Oxford Handbook of the Law of the Sea* (Oxford University Press, 2015), 46.

[21] Ibid. See also Article 293 of UNCLOS and Article 31(3) of the 1969 Vienna Convention on the Law of Treaties, adopted on 23 May 1969, entered into force 6 May 1975, 1155 UNTS 1980 (VCLT).

[22] Henrik Ringbom, "The Changing Role of Flag, Port and Coastal States under International Law" in Johan Schelin (ed), *General Trends in Maritime and Transport Law 1209–2009* (Axel Axelsons Institute of Maritime and Transport Law, University of Stockholm, 2009) 1. For a comprehensive analysis of the role of GAIRS in the UNCLOS, see Erik J Molenaar, *Coastal State Jurisdiction over Vessel-Source Pollution* (Kluwer Law International, 1998), 140–183.

[23] Maria Gavouneli, *Functional Jurisdiction in the Law of the Sea* (Martinus Nijhoff Publishers, 2007) 178; Chircop, note 15, 7; Ringbom, note 15, 163. As reported elsewhere, the advent of MASS can be seen as "a continuation of a trend that has been going on for centuries, where technology has taken over more and more functions on board." See The Swedish Club, note 3, 14. See also Eric van Hooydonk, "Botport Law—The Regulatory Agenda for the Transition to Smart Ports" in Baris Soyer and Andrew Tettenborn (eds), *New Technologies, Artificial Intelligence and Shipping Law in the 21st Century* (Informa, 2019), 90.

[24] Youri van Logchem, "International Law of the Sea and Autonomous Cargo Vessels" in Baris Soyer and Andrew Tettenborn (eds), *Artificial Intelligence and Autonomous Shipping* (Bloomsbury, 2021), 25–62, 40. See also Veal, Tsimplis, and Serdy, note 15, 25–30.

[25] Chircop, note 15, 28.

in this respect imposes responsibility on flag states to ensure navigational safety. Although admittedly flag states are given the right to define the conditions for ship registration,[26] in exercising their rights they are obliged to follow the basic principles and obligations to ensure safety of navigation. This goes hand-in-hand with the rights of coastal states. Here lies the lack of clarity as to whether the idea of MASS is compatible with UNCLOS and whether amendments would be needed to accommodate MASS.

In particular, it is unclear whether GAIRS would suffice for states to legalize MASS, or whether it is necessary for UNCLOS to undergo modifications[27]; ultimately, scholars take different positions.[28] With respect to remotely controlled ships, authors mostly opt for a flexible reading of UNCLOS to support the conclusion that the commercial employment of these ships would not necessarily call for any substantive changes to UNCLOS, but a combination of clarifications and amendments to the already existing IMO regulations representing GAIRS.[29] The idea of fully autonomous ships, however, encounters diverging opinions among scholars. Some put the main emphasis on the central role of the IMO in regulating maritime safety, including with respect to fully autonomous ships, and consequently do not engage in any discussions on the need for any new law-of-the-sea rule. Others are of the opinion that the idea of full autonomy is not fully compatible with UNCLOS.[30]

The key rule that calls for discussion in terms of the compatibility of MASS with UNCLOS, and the potential need for amendments to UNCLOS, is Article 94(3), which requires the flag state to ensure safety at sea by taking measures concerning *manning*, among others. Equally relevant is Article 94(4) of UNCLOS, which addresses the obligation of the flag state to ensure that each ship is

> in the charge of a *master* and *officers* who possess appropriate qualifications, in particular in *seamanship*, navigation, communications and marine engineering, and that the *crew* is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship.

[26] UNCLOS, Art 91(1).

[27] As a general rule, in delivering on their responsibilities under UNCLOS, flag states are required to conform to GAIRS as a regulatory minimum (Article 94(5) of UNCLOS).

[28] For a general comment, see Robin Churchill and Jacques Hartmann, "UNCLOS: Fit for Purpose in the 21st Century?," paper submitted on 10 October 2021, available at: https://committees.parliament.uk/writtenevidence/40805/pdf (accessed 6 November 2022).

[29] Chircop, note 15, 13; Ringbom, note 12, 458. Van Hooydonk, however, questions whether the idea of remote control center would comply with UNCLOS and such concepts as the right of visit (Articles 101, 102, 103) or the right of hot pursuit (Article 110). See Van Hooydonk, note 4, 410.

[30] For general comments and strict reading of the UNCLOS, see Churchill, note 28; Nautilus International, "UNCLOS: Fit for Purpose in the 21st Century?," paper submitted on 12 November 2021, available at: https://committees.parliament.uk/writtenevidence/40851/pdf (accessed 6 November 2022); Irini Papanicolopulu, Andrea Longo, and Daniele Mandrioli, "UNCLOS: Fit for Purpose in the 21st Century?," paper submitted on 12 November 2021, available at: https://committees.parliament.uk/writtenevidence/40874/pdf (accessed 6 November 2022). For a flexible reading of the UNCLOS, see Ringbom, note 12, 458; Ringbom, note 15, 161–162; Alexandros X. M. Ntovas, "Functionalism and Maritime Autonomous Surface Ships" in James Kraska and Young-Kil Park (eds), *Emerging Technology and the Law of the Sea* (Cambridge University Press, 2022), 214, 229. Chircop is rather cautious in flexible reading of the UNCLOS. See Chircop, note 15, 13.

"Manning" Does Not Equal "Attending"

Although in Article 94 of UNCLOS reference is made to terms such as "manning," "seamanship," "master," "officers," and the "crew," which intuitively imply the involvement of humans, UNCLOS does not explicitly require that a seafarer must be physically present on board a ship.[31] A manned ship is not necessarily an "attended" ship.[32] This would support the idea of remotely controlled ships, provided that technology enables remote navigation of the ship as safely as when humans are on board, which essentially boils down to the effectiveness of technology (cameras, sensors, radars, etc.). In other words, UNCLOS, as it currently stands, does not prevent an interpretation of Article 94 to accommodate remotely operated ships should the technology prove effective and safe enough.

Challenges With Fully Autonomous Ships

The situation with fully autonomous ships is somewhat complex, as the term *manned is* clearly opposite to the term *unmanned*. Closely related is the challenge with the "seamanship" requirement, which finds its origin in the 1972 International Regulations for the Prevention of Collisions at Sea (COLREGs).[33] In a recent judgement, the UK's Supreme Court referred to the COLREGs and held that

> Attempt was made by the respondent to use rule 2 as the basis for justifying a complete dis-application of the crossing rules as a matter of construction, on the basis of an apparent conflict with the rules of good seamanship, or to treat good seamanship on its own as a sufficient alternative to the application of the crossing rules, in relation to both the questions before the court. We regard this approach to rule 2 as being misconceived. [Referring to the Marsden & Gault on Collision at Sea] rule 2(a) "merely reminds seamen of the adverse consequences of failure to comply with the rules or with the practice of good seamanship" [and comes as a warning that no rule] terminate[s] the ever present duty of using reasonable skill and care.[34]

While making the point that good seamanship cannot be used as an excuse for disapplication of the crossing rules and does not exist in isolation from other rules of the road, the Court explicitly referred to the "ever present duty of using *reasonable* skill and *care*." The Court was arguably highlighting the role of a human in delivering on "good seamanship" (although the Court did not rule out the possibility that humans are located in a remote control center).[35] Nonetheless, a counterargument has been made that good seamanship does not necessarily demand the involvement of humans, as it essentially requires that whoever is navigating a ship does so in a thoughtful and

[31] This, for example, stands in clear contrast to Regulation VIII/2(2)(1) of the STCW, which demands a physical presence of the officers on the bridge for the watchkeeping purpose. See the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) adopted on 7 July 1978, entered into force 28 April 1984, 1361 UNTS 190, as amended.

[32] Ringbom, note 15, 157.

[33] The International Regulations for the Preventing of Collisions at Sea (COLREGs), adopted 29 December 1972, entered into force 30 August 15 July 1977, 1050 UNTS 16, as amended.

[34] *Evergreen Marine (UK) Limited v Nautical Challenge Ltd* [2021] UKSC 6 [66].

[35] Coito points out that, "as an initial matter, even the most intrepid programmer would struggle to translate the notion of 'good seamanship'—a human-focused, judgement-laden standard—into an autonomous system." See Coito, note 15, 303. See also Ringbom, note 15, 146 and 155; Ringbom, note 12, 434.

predictable manner.[36] This argument indeed opens up the possibility that good seamanship can be performed by artificial intelligence (AI), if AI delivers on thoughtfulness and predictability.[37]

Even if one takes the approach that AI is not able to comply with the requirement of *reasonable skill and care*, the COLREGs, as argued by Ringbom, "do not … rule out that autonomous navigation systems could be used to avoid having ships end up in a 'close quarters' situation in the first place."[38] Porathe has already put forward the argument that "AI might be able to predict a possible close quarters situations several hours ahead of a human navigator."[39] In this regard, AI fits well with the overall objective of early predictions and collision avoidance, and has the potential to improve maritime safety by addressing human shortcomings such as fatigue, attention span, information overload, and normality bias on the possibility of accidents.[40] The question would then remain: At what point should AI switch to human-performed and/or human-supervised navigation? If this is a reasonable interpretation of the COLREGs, UNCLOS could be interpreted in the same way.

In any event, as far as UNCLOS is concerned, the terminology used in Article 94, such as "manning," "master," "officers," "crew," and "seamanship," fails to attach any specific meanings that would rule out a functional interpretation of these terms.[41] This is important to observe in light of the fact that Article 94 refers not only to manning but to other measures as well, for example, construction, design, and equipment, all of which are related to navigational safety. In fact, Article 94 is not about manning, but about measures—the main objective of which is to ensure that seas and oceans are at all times navigated by seaworthy ships to establish and maintain safety of navigation, and protection of the marine environment accordingly. In the words of the International Court of Justice (ICJ), the choice made by states to opt for such generic terminology may indicate their intention to allow for a functional approach to interpretations.[42] Indeed, as mentioned earlier, the main reason why Article 94 of UNCLOS refers to GAIRS is to be flexible and dynamic in allowing technological developments

[36] Daniele Mandrioli, "The Rise of Autonomous Ships: Towards an Evolutionary Interpretation of the IMO Treaties on Safety of Navigation?" (2022) *Il Diritto Marittimo* 159, 174.

[37] This could remain a challenging task for technology to cope with, not least because no two ships behave identically for AI to be programmed on the basis of calculable data.

[38] Ringbom, note 15, 155.

[39] Porathe, note 8, 515; Thomas Porathe, Åsa Home, Ørnulf Jan Rødseth et al., "At Least as Safe as Manned Shipping? Autonomous Shipping, Safety and 'Human Error', Safety and Reliability—Safe Societies in a Changing World" in Proceedings of the 27th European Safety and Reliability Conference (ESREL 2018), Trondheim Norway. See also Mingyu Kim, Tae-Hvan Joung, Byongung Jeong et al., "Autonomous Shipping and Its Impact on Regulations, Technologies, and Industries" (2020) 4 *Journal of International Maritime Safety, Environmental Affairs, and Shipping* 17, 22; M.H. Lützhöft and S.W.A. Dekker, "On Your Watch: Automation on the Bridge" (2002) 55 *Journal of Navigation* 83, 83–96.

[40] Thomas Porathe, Åsa Home, Ørnulf Jan Rødseth et al., note 39, 5; M. H. Lützhöft and S. W. A. Dekker, note 39, 83, 83–96.

[41] As argued by Mandrioli, manning should in the context of unmanned ships be interpreted as a generic term capable of dynamic interpretation. See Mandrioli, note 36, 171.

[42] *Dispute Regarding Navigational and Related Rights* (*Costa Rica v. Nicaragua*), ICJ Reports 2009, p. 213 [57–71]. The evolutionary interpretation was also adopted in *Legal Consequences for States of the Continued Presence of South Africa in Namibia (South West Africa) Notwithstanding Security Council Resolution 276 (1970), Advisory Opinion,* ICJ Reports 1971 p. 16; *Aegean Sea Continental Shelf Case* (*Greece v. Turkey*) Judgment, ICJ Reports 1978 p. 3 [78]. As noted by Mandrioli, in the third report of International Law Commission, Special Reporteur Waldock included a provision that spelled out the following: "A treaty is to be interpreted in the light of the law in force at the time when the treaty was drawn up" (draft Article 56). However, this was not included in the final text. See Mandrioli, note 36, 167, fn. 47.

and to avoid what Ringbom calls the "freezing" of shipping regulations. If the fundamental purpose of Article 94 is to ensure that each ship is operated and navigated safely and competently, one may assume that whether a ship is attended by humans, controlled remotely, or controlled fully autonomously, there is no difference in terms of UNCLOS as long as the technical equipment has the appropriate level of competence to ensure navigational safety, at least to the same extent as required from conventional ships.[43] In simple terms, the object and purpose of Article 94(4) of UNCLOS would then permit the interpretation that human control is relative to specific types of ships where technology cannot compensate for human interventions. If this is the correct interpretation, clarifications[44] through the key IMO conventions would still be desirable to prevent further misunderstandings, but arguably no substantial amendment to UNCLOS would be necessary in this regard.[45]

This conclusion does not imply that the employment of MASS is without challenges whatsoever. For example, it is worth noting at this stage that there is a problem with the decision-making process when ships are in distress and need a place of refuge.[46] Here an immediate back-and-forth communication between the ship and other stakeholders (coastal authorities, salvor, captain on board the ship, etc.) may prove vital in making decisions on the best possible response to crises at sea. Another problem relates to the duty of the master to render assistance to persons in distress at sea.[47] These issues are not, however, the focus of this article. What remains to be discussed now is whether and to what extent the existing regulations on ships' routing, ship reporting, and VTS reveal flexibility to accommodate MASS.

Zooming In: Ships' Routing, Ship Reporting, and VTS

MASS and Ships' Routing Regulations

Ships' routing is the most basic safety measure to regulate navigation and reduce the risk of casualties and pollution.[48] Traditionally associated with only one specific measure—sea lanes and traffic separation scheme (TSS), as regulated under the Rule 10 of COLREGs and under Articles 22 and 41 of UNCLOS (addressing the regimes of the territorial sea and straits used for international navigation respectfully)—ships' routing has undergone significant developments under the 1974 International Convention

[43] See also Ntovas, note 30, 229.

[44] Some sort of a glossary, see LEG.1/Circ.11, 15 December 2021.

[45] If, however, one wishes to engage in the argument that UNCLOS would need to be modified, it is interesting to observe a certain trend where states do tend to engage through the forum of the IMO to discuss the law of the sea issues as long these are related to shipping. Ringbom has already observed modifications under SOLAS. See Ringbom, note 22, 8. The potential of the modificatory character of the recent developments with the 2007 Nairobi International Convention on the Removal of Wrecks has also been noticed. See Iva Parlov, "The 2007 Nairobi International Convention on the Removal of Wrecks: The Implications for the Law of the Sea" (2022) 36 *Ocean Yearbook* 659. M'Gonigle and Zacher envisaged the pivotal role of the IMO in contributing to the development of the law of the sea regime concerning shipping when arguing at the time of UNCLOS III that "demands will arise again for IMCO to act in the face of ambiguities or omissions in the law of the sea." See Michael M'Gonigle and Mark Zacher, *Pollution, Politics, and International Law* (University of California Press, 1979) 77.

[46] Chircop, note 15, 17.

[47] UNCLOS, Art 98(1)–(2).

[48] IMO Assembly Resolution A.572(14), of 20 November 1985, as amended, Annex *General Provisions on Ships' Routeing* (GPSR), [1.1.].

for the Safety of Life at Sea (SOLAS),[49] and therein incorporated General Provisions on Ships' Routeing (GPSR).[50] Such measures now also include two-way routes, recommended tracks, areas to be avoided (ATBA), inshore traffic zones, roundabouts, precautionary areas, and deep water routes, and also extend beyond the territorial sea.[51]

According to SOLAS (Regulation V/10), the coastal state is entitled to impose a *mandatory* ships' routing system on foreign ships. The argument that IMO approval must in this respect be obtained in relation to *any* maritime zone has been subject to some discussion among scholars.[52] Owing to the nonprejudicial effect of SOLAS on UNCLOS,[53] the majority of scholars agree that IMO approval is, in principle, not required in the territorial sea,[54] although there is differing state practice on this, depending on the type of measure in question, such as the establishment of mandatory areas to be avoided (ATBA).[55] The majority of delegates at the IMO have historically taken the view that the adoption of mandatory ATBA is consistent with UNCLOS and the regime of innocent passage only if adopted by the IMO.[56] New Zealand, for example, obtained the approval from the IMO when establishing ATBA in an area exclusively

[49] See Regulation V/10.

[50] IMO Assembly Resolution A.572(14), of 20 November 1985, as amended, Annex *General Provisions on Ships' Routeing* (GPSR).

[51] Despite the fact that UNCLOS does not make any explicit reference to measures of ships' routing other than sea lanes and traffic separation scheme, it has been argued that UNCLOS does not exclude the adoption of these measures, at least not as far as the territorial sea is concerned. The main argument in this respect relies on the broad coastal state regulatory jurisdiction, including over issues concerning "the safety of navigation and the regulation of marine traffic" (Article 21(1)(a) of UNCLOS). Article 22 of UNCLOS (sea lanes and traffic separation scheme in the territorial sea) should accordingly be interpreted extensively. For more on this argument see Molenaar, note 22, 203–204; Henrik Ringbom, *The EU Maritime Safety Policy and International Law* (Martinus Nijhoff Publishers, 2008), 441. See also Richard Barnes on Article 22 of the United Nations Convention on the Law of the Sea in Alexander Proelss (ed), *United Nations Convention on the Law of the Sea; A Commentary* (C. H. Beck, Hart, Nomos, 2017), 212. According to some scholars, coastal state regulatory jurisdiction over broad ships' routing system could also be justified on the basis of Article 211 of the UNCLOS—environmental jurisdiction, which would then include the exclusive economic zone (EEZ). See Daniel Bodansky, "Protecting the Marine Environment from Vessel-Source Pollution: UNCLOS III and Beyond" (1991) 18 *Ecology Law Quarterly* 719, 751. See also Molenaar, note 22, 204; Ringbom, ibid.

[52] This is mostly due to the ambiguous language of both UNCLOS (Article 22 and 41) and SOLAS, Regulation V/10. As far as straits used for international navigation are concerned, the fact that UNCLOS (Article 41(4)) requires states to refer their proposals to the IMO led Bartenstein and Chircop to maintain the view that IMO approval is indeed necessary. See Kristin Bartenstein, "The 'Arctic Exception' in the Law of the Sea Convention: A Contribution to Safer Navigation in the Northwest Passage" (2011) (42) *Ocean Development & International Law* 22, 37; Aldo Chircop, "Maritime Autonomous Surface Ships in International Law: New Challenges for the Regulation of International Navigation and Shipping" in M. Nordquist, John Norton Moore, and Ronan Long (eds), *Cooperation and Engagement in the Asia Pacific Region* (Brill, 2019), 18, 25–26. Given that the coastal state is at all times obliged not to hamper innocent and transit passage (Articles 24 and 44 of UNCLOS), Oxman takes the view that if the coastal state ignores or goes against the IMO's recommendation or does not even ask for it, it may risk violating such obligations. Conversely, as Oxman argues, the coastal state is in a strong position when it implements the IMO recommendations. See Bernard H. Oxman, "Environmental Protection in Archipelagic Waters and International Straits: The Role of the International Maritime Organization" (1995) 10 *International Journal of Marine and Coastal Law* 469.

[53] SOLAS, Regulation V/10(10).

[54] See Molenaar, note 22, 213; Lindy S. Johnson, *Coastal State Regulation of International Shipping* (Oceana Publications, 2004), 71–73. For the opposite view see Glen Plant, "The Relationship between International Navigation Rights and Environmental Protection: A legal Analysis of Mandatory Ship Traffic Systems" in Henrik Ringbom (ed), *Competing Norms in the Law of Marine Environmental Protection, Focus on Ship Safety and Pollution Prevention* (Kluwer Law International, 1997), 11, 21–22.

[55] Henrik Ringbom, *The EU Maritime Safety Policy and International Law* (Martinus Nijhoff Publishers, 2008), 441; Molenaar, note 22, 213.

[56] See IMO Doc. 64/22, [9.9]., and 63/7/19, 25 March 1994; See also Julian P. Roberts, *Marine Environment Protection and Biodiversity Conservation: The Application and Future Development of the IMO's Particularly Sensitive Sea Area Concept* (Springer, 2007), 122–126.

within the limits of the territorial sea.[57] In the EEZ the IMO approval is in any event *conditio sine qua non*.[58]

The next few subsections elaborate on the question of where the focus lies in the existing IMO regulations on ships' routing and what would appear to be the key challenge in adopting ships' routing concerning MASS.

Focus on the Function

When one looks at existing IMO regulations concerning the TSS, who navigates the ship and from which location appear to be irrelevant. Under Rule 10 of COLREGs, the duty to follow the TSS is imposed on a "vessel," rather than a vessel specifically navigated and attended by a *human*. On the premise that MASS are vessels/ships,[59] there would seem to be no reason to conclude that the idea of MASS does not fit into IMO's regulations addressing the TSS. This conclusion would then equally apply to both remotely controlled and fully autonomous ships. Concerning the other types of routing measures (recognized explicitly under SOLAS, but not explicitly under UNCLOS), a conclusion could be drawn from Regulation V/10(7) of SOLAS, which explicitly spells out the duty of a "ship" to use a mandatory ships' routing system, and thus makes no reference to any specific characteristics of such a ship, that is, *who* navigates the ship and from *where*.

The GPSR, on the other hand, are based on the assumption that ships' routing is utilized by "mariners," rather than merely by *ships*.[60] However, in addition to the fact that the GPSR are of a non-legally binding nature, the term "mariner" is not defined in any specific way and certainly does not demand that humans be physically present on board a ship.[61] Even with respect to fully autonomous ships, a functional interpretation should not be ruled out.[62] The GPSR maintain the approach that measures associated with routing (e.g., pilot boarding areas or aids to navigation) are important for "effective utilization [of the system] by the mariner."[63] This would suggest the main task of the mariner revolves around the *effective use* of the system. If AI enables the ship to *effectively* use ships' routing, the question of *who* navigates the ship and *from where* would have a minor influence, if any. Given the emphasis placed on the "effectiveness," a constructive interpretation would theoretically seem feasible in relation to both remotely controlled and fully autonomous ships, if technology indeed delivers on effectiveness without the need of human involvement. Clarification in terms of the key terminology (e.g., "mariner") would nonetheless be advisable.[64]

[57] See Julian P. Roberts, ibid, 122–126.

[58] See Molenaar, note 22, 213; Ringbom, note 56 442; Lindy S. Johnson, note 55, 71–73.

[59] Kraska concludes the same. See James Kraska, "The Law of Unmanned Naval Systems in War and Peace" (2010) 5 *Journal of Ocean Technology* 64.

[60] See GPSR, [3.6.], and also [3.2.1.], [3.1.3.], [5.7.1.].

[61] Cambridge Dictionary, available at: https://dictionary.cambridge.org/dictionary/english/mariner (accessed 3 April 2023).

[62] For constructive treaty interpretation in jurisprudence, see the *Dispute Regarding Navigational and Related Rights (Costa Rica v Nicaragua)*, Judgment, ICJ Reports 2009 p. 213, [63–64].

[63] See GPSR, [3.6.], and also [3.2.1.], [3.1.3.], [5.7.1.].

[64] In any discussion on MASS, there is a typical "horizontal" issue in that the definition of the master for the purpose of MASS could solve a large number of identical issues crossing different IMO regulations. See Ringbom, note 12, 438. LEG.1/Circ.11, 15 December 2021.

Challenges With Coexistence of MASS and Conventional Ships

The discussion so far aligns with general observations that IMO regulations place an emphasis on a given function.[65] This indeed allows one to conclude that MASS could fit into the existing regulations without significant regulatory modifications, as long as the technology is capable of fulfilling the desired function. At the same time, it is important to bear in mind that the coastal state must not infringe the navigational rights and freedoms when adopting ships' routing for MASS.[66] This point is relevant in the context of coexistence of MASS and conventional ships, and merits some further discussion.

The general idea and premise made in the IMO's Interim Guidelines is that MASS will have to ensure at least the same degree of safety, security, and protection of the environment as provided by conventional ships.[67] In other words, MASS alone should not be treated any differently than conventional ships. If anything, MASS should be safer than conventional ships (the IMO Guidelines speak of the degree that is *at least* as safe as for conventional ships). In this respect, MASS should not be considered a subcategory of ships but rather, ships or vessels in general.[68] On this assumption, if the coastal state is prohibited from making all ships subject to ships' routing on the mere basis of the fact that these are ships, the coastal state would then be equally prevented from making all MASS subject to routing solely based on the fact that these ships are MASS.

At the same time, if nuclear ships are considered a special "safety" category due to a different way of being propelled, the same could be said for MASS and their different mode of navigation.[69] This is important to reflect upon as the continuous scientific uncertainties and the lack of previous experience with MASS could arguably warrant more precaution in terms of space division between MASS and conventional ships, especially in congested areas.[70] In this respect, to address the novel risk of combined navigation between MASS and conventional ships, the coastal state could wish to adopt a routing system separate from the conventional one. From a legal point of view, a coastal state may not adopt regulations that would deny innocent passage.[71] However, as the right of innocent passage does not equal the right to choose a navigational route, there would be nothing in principle to prevent a coastal state from requiring MASS to follow separate routing, if this is indeed necessary to ensure safety of navigation.[72] There is already an argument that the new traffic organization, which would combine and distinguish between autonomous routes and standard routes, would

[65] Henrik Ringbom, "Legalizing Autonomous Ships" (2020) 34 *Ocean Yearbook* 431, 437.

[66] UNCLOS, Arts 24 and 44.

[67] IMO Interim Guidelines, [2] (Principles and Main Objectives).

[68] A similar observation was made by Anna Petrig in a webinar organized by the Centre for International Law (National University of Singapore) on 18 January 2022 to address a variety of issues with the advent of MASS (notes on file with the author).

[69] The author is grateful to the anonymous reviewer for this observation.

[70] As noted in one Danish report: "Narrow waters and vessels with limited maneuverability, for example, owing to their size and draught, are especially challenging—both for navigating officers and for algorithms that are to be able to ensure autonomous navigation." See Mogens Blanke, Michael Henrikes, and Jakob Bang, "A Pre-Analysis on Autonomous Ships," 2016, available at: https://www.dma.dk/Media/637745503398246035/Autonome%20skibe_DTU_rapport_UK.pdf (accessed 2 April 2023).

[71] UNCLOS, Art 24.

[72] On the basis of the extensive reading of Article 21 of the UNCLOS. See note 59.

significantly contribute to safety, especially if made mandatory, as lessons have already been learned after the introduction of the Electronic Chart Display and Information System (ECDIS), which caused a "shift in the traffic pattern" as ships, in an attempt to save sailing time and costs, tend to take short-cuts rather than the normal route.[73]

A concern exists in that creating additional routes for autonomous ships could limit space for other activities, which may be problematic in the context of the already increasing competition for space.[74] Moreover, there could be the actual (un)feasibility of having different routing for different types of ships in a narrow space, regardless of any other activity taking place; the use of straits is an example. Compulsory pilotage or towage is perhaps a solution, but could trigger disagreements in relation to navigational rights, and the question of whether or not the approval of the IMO is necessary. As argued by Rothwell with respect to compulsory pilotage imposed on conventional ships, the IMO's approval would seem to be needed, as state practice indicates.[75] However, if compulsory pilotage or towage appears to be necessary in order to respond to the safety risk of combined navigation, insisting on IMO approval could essentially negate territorial sovereignty and the regulatory power already given to the coastal state under Articles 21 and 22 of UNCLOS. This author therefore takes the view that the approval of the IMO is not necessary, at least not in theory, save for perhaps when it comes to straits used for international navigation (as Article 41 of UNCLOS explicitly obliges states to refer their proposals to the IMO), but one should still bear in mind the arguments made by Rothwell and the state practice he referred to. In the EEZ separate routing may be unnecessary, as there is generally more space for maneuver than in congested areas of the territorial sea or international straits. If, however, the coastal state wishes to engage in such a regulatory task, it would need the consent of the IMO, as explained earlier. Moreover, it would need to justify such routing regulations on the basis of environmental jurisdiction, as there exists no legal basis for the adoption of such measures with respect to pure safety considerations.[76]

MASS in the Context of Ship Reporting and VTS

Ship reporting is normally operated as a VTS, although it is not always necessarily the case. Similar to the routing system, the objective of both ship reporting and VTS is to assist a ship in an endeavor to ensure safety of life at sea, safety and efficiency of navigation, and protection of the marine environment.[77] Although none of these systems are addressed explicitly under UNCLOS, their objective fits well within UNCLOS's overall safety and environmental narrative.[78] Somewhat specific, but still

[73] Tore Relling, Margareta Lützhöft, Runar Ostnes et al., "The Contribution of Vessel Traffic Service to Safe Coexistence between Automated and Conventional Vessels" (2022) 49 *Maritime Policy & Management* 990, 997. This study and its findings are based on the experience of some of the VTS experts and officers.

[74] See Barnes, note 58, 212.

[75] See Donald R. Rothwell, "Compulsory Pilotage and the Law of the Sea: Lessons Learned from the Torres Strait" (2012) *ANU College of Law Research Paper No. 12-06*, 2. Kachel, on the other hand, maintains the view that the approval from the IMO would only be needed in the EEZ. See Markus Kachel, *Particularly Sensitive Sea Areas: The IMO's Role in Protecting Vulnerable Marine Areas* (Springer, 2008), 203.

[76] UNCLOS, Art 211(5). See Ringbom, note 56, 442, fn 232.

[77] SOLAS, Regulations V/11(1) and V/12(1)

[78] It has been argued that ship reporting and VTS, despite not being explicitly recognized under UNCLOS, are in principle to be regarded as consistent with UNCLOS. As noted by DOALOS, "Through the adoption of [SOLAS],

limited, regulations on ship reporting and VTS are found in SOLAS and therein incorporated IMO guidelines and principles.[79]

According to SOLAS, states have a right to establish a VTS "where, in their opinion, the volume of traffic or the degree of risk justifies such services."[80] The term "degree of risk" does not imply the nature of the risk, nor does it refer to specific characteristics of a ship, which would preclude the use of VTS by MASS. However, it is the "master" who normally interacts with the VTS and agrees on the VTS sailing plan.[81] Indeed, the IMO guidelines and principles concerning ship reporting and VTS imply that these systems are used by the "mariners" or by the "master."[82] According to SOLAS, the reporting duty, which is naturally also part of the VTS system,[83] is imposed on the "master."[84] In the same vein, the duty to enter technical failures into the ship's log rests with the "master."[85]

Although the master is occasionally referred to as being in charge of navigation,[86] it is not stipulated where the master must be located to be able to fulfill this duty. There is therefore nothing to prevent the remote center from performing the duties of the master. As far as fully autonomous ships are concerned, the terms "mariners," "master," and so on intuitively imply the involvement of humans. However, no definition of the term "master" is provided. A simple focus on the objective of the reporting system (no back-and-forth interactions) and the efficiency of its service could lead to a flexible definition of the term "master," so as to cover both remote control centers and AI, although clarification to this end would again be advisable. On the other hand, communication within the VTS system, as well as among ships themselves, is not confined to MASS alone. The question therefore persists in terms of whether the system may continue to be effectively used by AI. These points are next discussed in more detail.

Passive Reporting: "Fit for Purpose"

The reporting system is about the communication of data, which is required to be "clear and simple and avoid imposing an undue burden on masters, officers of the watch and pilots."[87] A system that automatically transmits, analyzes, and acts upon

States have already agreed implicitly that notification of entry into an [reporting] area would not impede freedom of navigation." See IMO Doc., LEG 87/17 of 23 October 2003, Annex 7, 2. The controversial issue is rather whether the coastal state needs to obtain approval from the IMO or may adopt these measures unilaterally. As with ships' routing, the majority in legal scholarship takes the view that no IMO approval is needed within the territorial sea. See Molenaar, note 22, 214; Ringbom, note 55, 447–448. Oxman, however, takes the view that any unilateral action by the coastal state may risk violating the obligation not to hamper innocent and transit passage. See Bernard H. Oxman, "Environmental Protection in Archipelagic Waters and International Straits: The Role of the International Maritime Organization" (1995) 10 *International Journal of Marine and Coastal Law* 469.

79 A revised version of SOLAS, chapter V "safety of navigation" adopted in 2000, entered into force in 2002.

80 SOLAS, Regulation 12(2).

81 VTS Guidelines, [3.1.2.5].

82 IMO Doc, MSC 98/23/Add.1, of 30 June 2017, Annex 17, *IMO Guidelines and Criteria for Ship Reporting System*, [3.2.1.]; VTS Guidelines, introductory note, 2, [3].

83 VTS Guidelines, [3.1.4], [4.4].

84 SOLAS, Regulation 11(7).

85 IMO Guidelines and Criteria for Ship Reporting Systems, [2.4.2]. See also SOLAS, Regulation V/11(7).

86 VTS Guidelines, [7.1.]. See also introductory note to the Guidelines, 2, [3].

87 IMO Guidelines and Criteria for Ship Reporting System, [2.2.1.2].

data enables faster communication, smoother navigation, and increased operational efficiency.[88] If the emphasis is placed on the requirement of "clear and simple," of which the aim is to take the burden away from humans, that is, "to reduce ships' reporting burden,"[89] a more flexible approach to interpretation could be justified to potentially view AI as performing the role of the "master" in using the reporting system.

Admittedly, the IMO Guidelines on ship reporting speak of radio communication,[90] which does not easily translate to AI, but these guidelines do not exclude an alternative means of communication, as the communication may happen via either radio or other electronic means recognized by the IMO.[91] In addition, according to these guidelines, "*if* verbal communications are used, the language should enable the shore-based authority and the participating ship to understand each other clearly."[92] Verbal communication does not necessarily entail speaking. Moreover, the term "verbal" is used in combination with the term "if," which clearly indicates that there may also be a form of nonverbal communication in place. This therefore confirms the rather passive and technology-neutral character of reporting.

In planning or revising a reporting system, states are expected to take into account factors such as equipment requirements, and method of ship-to-shore communication and data processing, "so as to ensure reliability and clear communication between the shore-based authority and participating ships."[93] This is thus again about a certain function—*communication*—whatever makes it reliable and clear. If AI responds to the quest of "reliable and clear communication," the questions of *who* and *from where* should have a minor, if any, role in defining the term "master" for this particular purpose. Theoretically speaking, AI could perform the very basic duty of reporting, provided there is adequate reliability and standardization in place so that different technologies follow the same standards to prevent potential misunderstandings on the side of the receiver. There are certain systems already in place, such as SafeSeaNet, that may simplify the administrative burden in communication and increase information flow and transparency of data.[94]

Indeed, as observed by Chircop, a fully autonomous ship will likely possess an electronic log and reporting will simply follow the current trend, which makes documentation requirements satisfied by way of electronic means and makes reporting increasingly passive.[95] All this goes to say that the communication requirement in the ship reporting system ("one-way" communication) may in principle accommodate both

[88] GARD, note 5, 24. See also H. Dybvik, E. Veitch, and M. Steinert, "Exploring Challenges with Designing and Developing Shore Control Centres (SCC) for Autonomous Ships," International Design Conference- Design 2020, available at: https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2726074/exploring_challenges_with_designing_and_developing_shore_control_centers_scc_for_autonomous_ships.pdf?sequence=2&isAllowed=y (accessed 3 April 2023).

[89] IMO Guidelines and Criteria for Ship Reporting System, [2.2.2.1].

[90] Ibid, [2.3.2] and [2.4.2].

[91] Ibid, [2.3.2].

[92] Ibid, [2.2.1.2].

[93] Ibid, [3.2.2.4]; Guidance Note on the Preparation of Proposals on Ships' Routeing Systems and Ship Reporting Systems for Submission to the Sub-Committee on Safety of Navigation, IMO Doc MSC/Circ. 1060, Annex, [6.2.3.4].

[94] European Maritime Transport Environmental Report 2021, note 5, 124.

[95] See also Chircop, note 15, 30.

remotely controlled and fully autonomous ships. In reality, much of the ship reporting in fact happens automatically.[96]

Challenges With Effective Human–Machine Interactions

In contrast, communications with VTS officers, and between ships themselves, are interactive by nature and do raise concerns, not least in terms of the use of radio channels. For an effective interaction between a VTS, MASS, and conventional ships, it is critical that the shore-based authority and the participating ship "understand each other clearly,"[97] and on time, so that the master can receive and act upon the necessary information, advice, warning, or instruction received from the VTS.[98] The quality of accident prevention measures is certainly dependent on the system's ability to give timely warning of dangers.[99] In this respect, the use of radio by humans is sensible. Whereas communication by radio may conceivably be performed by a remote operator, it does not easily extend to an algorithm, and to some extent rightfully so. Borrowing from Chircop, "two-way communication involving a machine on the autonomous vessel and humans on vessels in its vicinity (for instance using very high frequency radio (VHF) to avoid close quarters) may not be possible, let alone desirable."[100] If a VTS officer is to communicate back and forth with a preprogrammed AI system to provide the necessary advice, there is a risk of misunderstanding or no understanding whatsoever. In the absence of prompt and effective communication within VTS systems, the rather low-key event on board the ship could rapidly evolve into a maritime casualty where any response is already more of a remedial effort than preventive in character.[101] At the same time, it was emphasized earlier in this article that radio does not have to be the only means of communication, but the challenge persists as the VTS is at present performed by humans.

It is not hard to imagine a futuristic scenario of smart ports where AI acts as a VTS officer,[102] and where autonomy is put in a broader context of autonomous *systems*

[96] Ringbom points at the comparison with the content of AIS information, as captured under the IMO Assembly Resolution A. 1106(29), of 14 December 2015, *Revised Guidelines for the Onboard Operational Use of Shipborne Automatic Identification Systems (AIS)*. See Ringbom, note 56, 448. Of some controversy could be the question of prior notification. If the coastal states would prefer to get notified far in advance about MASS entering its waters (rather than shortly before the entry) to be better prepared for organizing combined navigation, this could be perceived as an intrusion on passage rights and the approval from the IMO would be necessary. Prior notification was a sensitive issue that could not have been solved during UNCLOS III. See Molenaar, note 22, 198, 216. Yet, as much of the ship reporting indeed happens automatically, the problem with prior notification, if any, would emerge only if a given information relates to something that is not already transmitted by AIS, which at this stage is an unclear issue.

[97] IMO Guidelines and Criteria for Ship Reporting System, [2.2.1.2].

[98] VTS Guidelines, [3.2], [6.1.2], [7.3].

[99] See also IMO Guidelines and Criteria for Ship Reporting Systems, [2.2.1.6].

[100] Chircop, note 15, 14. In the words of Porathe, "Every one of us that are struggling with the complexity of digital tools know that they do not always do what we want or assume they will do. They 'think' differently from us." See Porathe, note 8, 515.

[101] Palmer Cundick, "High Seas Intervention: Parameters of Unilateral Action" (1972–1973) *San Diego Law Review* 514, 519. For legal analysis on different stages of perils at sea, see Iva Parlov, *Coastal State Jurisdiction over Ships in Need of Assistance, Maritime Casualties and Shipwrecks* (Brill, 2022).

[102] Van Hooydonk, note 23, 90–104. The trend of automation and digitalization is equally affecting ships and on-shore facilities and decision-making systems. Kongsberg is pioneering automated data analytics that use artificial intelligence (AI) to assist vessel traffic service (VTS), typically performed by human operators. See Kongsberg, "Using Data Analytics to Shape the Future of Maritime Domain Awareness" (2022), *Kongsberg,* available at: https://www.kongsberg.com/no/kda/news/news-archive/2021/using-data-analytics-to-shape-the-future-of-maritime-domain-awareness/ (accessed 6 November 2022).

(rather than only autonomous *ships*). In this sense, machines would communicate with machines. However, conventional ships (and potentially remotely operated ships) will continue to navigate our seas and oceans. An individual system thinking would thus not be tenable but rather a more holistic system-of-systems thinking.[103] One could perhaps expect the need for a human to at least monitor whether calculations made by individual systems are properly taken into account by all actors involved, including conventional ships, and to go a step further (where necessary) to advise, warn, or instruct the ship to take immediate action. The VTS officers would, in this respect, need to be specially trained and certified to perform VTS services.[104]

Reality at Present: The Increased Need for Systems Inclusive of (Some) Humans

At present, despite the quite fascinating technological developments, the involvement of (some) humans *on board the ship* seems to remain critical, as witnessed through the fact that the attention to redundant systems is seemingly decreasing; and the need for systems inclusive of (some) humans increasing.[105] In fact, the start of 2022 was marked by MASS trials in Japanese waters that involved a 240-kilometer-long autonomous voyage of the large car carrier *Soleil*. The ship was navigated from the Super Bridge-X autonomous navigation system, equipped with AI and deep learning technologies, AIS, infrared cameras and radars, and a target image analysis system, which altogether replaces the need for human control. The ship seemingly passed fishing vessels and tankers in the nearby area without any concern, which speaks to full autonomy being successfully performed. However, a human operator *did* take the control at one point during the voyage to ensure a vessel in close proximity to *Soleil* was not alarmed. The chief engineer stated that "the system operated normally. Because it was displaying a route that might have caused *the crew of the other vessel* some concern, the captain took the precaution of performing a manual avoidance maneuver."[106] It therefore becomes particularly appropriate to recall what one commentator has recently observed in that "there are two schools of thought: one suggests technology aids mariners, the other argues that mariners aid technology. Best performance comes as mariners and technology complement each other."[107] This "complementing" role, however, does come with the issue of overreliance on technology, which has always been a problem in shipping, as Chircop warns.[108] It is also worth noting that lessons can be learned from previous experiences with the "switching on–off" witnessed in

[103] See Relling, Lützhöft, Ostnes et al., note 74.

[104] For similar observations in relation to smart ports, see Van Hooydonk, note 23, 99.

[105] Relling, Lützhöft, Ostnes et al., note 74, 990.

[106] Nippon, "Japanese Consortium Ticks Off Autonomous Shipping Milestone" 28 February 2022, *Nippon* available at: https://www.nippon.com/en/japan-topics/g02047 (accessed 3 April 2023) (emphasis added).

[107] *Lloyd's List* available at: https://lloydslist.maritimeintelligence.informa.com/LL1137295/Why-technology-training-is-best-preparation-for-digital-shipping (accessed 6 November 2022). The observation was also made by Wright, president of GMATEK, that "possible solutions would be to keep humans in the loop for monitoring and decision support." As Wright points out, "[w]e need help from labour, keeping seafarers in the loop […] but their roles will be changing and evolving." See Riviera News, "AI Improves Navigation Safety, but Comes With Challenges," 31 January 2022, *Riviera,* available at: https://www.rivieramm.com/news-content-hub/ai-improves-navigation-safety-but-comes-with-challenges-69416 (accessed 6 November 2022).

[108] Chircop, note 15, 25. For similar thoughts, see van Hooydonk, note 23, 98.

the automobile and aircraft industry. During the Air France Flight 447 in 2009, when the autopilot transferred control over the aircraft back to the human (pilot), the latter was caught by surprise and overwhelmed by information overload, which, under the circumstances of flashlights and loud warning signals, led to loss of cognitive control of the situation (as reported by French officials).[109]

Concluding Remarks

MASS are claimed to bring many opportunities to our society, not least in terms of operational efficiency and safety of the crew, while promising fewer emissions and greener shipping. On the assumption that MASS will prove safe enough to ply our seas and oceans, this article has investigated whether the current international law of the sea regulatory framework is ready for such autonomy. As revealed in this article, the compatibility of the idea of MASS with UNCLOS does not seem to be an issue when it comes to remotely controlled ships. Although Article 94 of UNCLOS speaks of a manned ship, the latter is not necessarily an attended ship. As far as fully autonomous ships are concerned, legal scholarship remains split. The key problem in this respect concerns the fact that manning is opposite to "unmanned," and that the master and officers must possess appropriate qualifications in seamanship and communication. Yet neither the task of "communication" nor "seamanship" is defined any further. This author takes the view that the requirement of manning could be interpreted constructively so to be relative to ships' characteristics and would not rule out the IMO's mandate as a competent international organization to accommodate technological developments in shipping through the development of GAIRS.

The aptness to autonomy is also present in the existing IMO regulations on ships' routing. Although terms such as "mariners" and the "master" are occasionally used, the definitions of these are absent; rather than focusing on who is manning the system, the emphasis is placed on its effective use. This, combined with the fact that routing essentially concerns the simple task of navigation, could enable functional interpretations. When it comes to the reporting and VTS systems, the situation is somewhat, but not entirely, different. The use of these systems continues to be in the hands of the "master," again not clearly defined. Further clarification of key terminology would be advisable to move forward with bringing MASS to the waterways. However, a back-and-forth communication between AI and VTS raises serious concerns, especially as VTS remains to be performed by humans. In contrast, a simple passive reporting does not seem to raise any particular worries if performed either by AI or by operators in a remote control center.

Although much of regulatory focus is placed on the effectiveness of technology (and the past has taught us that technology indeed finds a way to prove its use), at this stage one cannot help but question such effectiveness in risky situations that demand quick reactions that are predictable in relation to conventional ships in the vicinity.

[109] Council of Europe Study, "Responsibility and AI," DGI (2019)05, 59 and 66. Similar problem occurred with the Uber accident, as pointed out in the same report.

This may partly explain why there is a recent trend focusing on the increased use of automatization to *support* rather than to *replace* regular manned operations.[110]

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[110] Relling, Lützhöft, Ostnes et al., note 74, 990; The Swedish Club, note 3.