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I. INTRODUCTION

The advent of autonomous vessel technology heralds a new future for activities on the world's oceans. In the brightest vision of this future, global maritime shipping will be more efficient and ecologically sound, rescuers will have unprecedented ability to locate and assist those in peril at sea, and maritime law enforcement officers will wield heretofore unknown tools to interdict illicit maritime trafficking. In contrast to the promise of this vision lies the sobering reality that autonomous vessels challenge the existing international order of the seas, from collision avoidance to safe manning and beyond. This article examines the extent to which the existing international order can address the challenges posed by autonomous vessel operations. It does so through the lens of the U.S. Coast Guard, whose legal authorities and operational capabilities as an armed force, law enforcement agency, and industry regulator provide a unique vantage for understanding the promise and perils of autonomous vessel technology. Specifically, this article will analyze autonomous vessel technology in the context of three core Coast Guard mission areas: (1) search and rescue, (2) maritime counterdrug operations, and (3) navigational safety. It will argue that the dawn of autonomous vessels—a watershed moment in personal and digital maritime mobility with great potential for aiding humanity—is not an unmitigated good. Indeed, autonomous vessels are of singular importance precisely because of their capacity for misuse and even disaster.

A. The Era of Autonomy

The era of autonomous vehicles is upon us. The ride-hailing company Uber is actively testing self-driving cars.[1] Blue Origin and SpaceX, prominent commercial space companies, have successfully conducted "autonomous precision landings" of their rockets.[2] Semi-autonomous trucking is already underway, disrupting an industry that moves over half of the goods shipped in the

1. *See Autonomous Vehicles are Just Around the Corner*, THE ECONOMIST (Mar. 1, 2018), https://www.economist.com/special-report/2018/03/01/autonomous-vehicles-are-just-around-the-corner.

2. Lars Blackmore, *Autonomous Precision Landing of Space Rockets*, *in* FRONTIERS OF ENGINEERING 33 (Ronald M. Latanision ed., 2016).

United States.[3] These rapid advances suggest that autonomous vessel technology may well "revolutionize personal and commercial transportation" as we know it.[4]

A key component of this nascent era of autonomy is taking place on the world's oceans.[5] In the commercial context, international shipping is "on the verge of a technological revolution"—the rise of maritime autonomous surface ships (MASS).[6] For example, in 2018, Rolls-Royce and Finnish state-owned ferry operator Finferries successfully navigated the ferry *Falco* under fully autonomous control.[7] According to Mikael Makinen, president of Rolls-Royce Marine, "[a]utonomous shipping is the future of the maritime industry," where it will be "as disruptive as the smartphone."[8]

But autonomous vessel developments have not been limited to commercial applications. Indeed, enterprising naval forces have been the prime mover of autonomous vessel technology, with a profound catalyzing effect on the design and implementation of unmanned vehicles.[9] The U.S. Navy

3. Aisha Chottangi, Greg Hastings, John Murnane & Florian Neuhaus, *Distraction or Disruption? Autonomous Trucks Gain Ground in US Logistics*, MCKINSEY (Dec. 10, 2018), https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/distraction-or-disruption-autonomous-trucks-gain-ground-in-us-logistics.

4. *See* Jeremy A. Carp, *Autonomous Vehicles: Problems and Principles for Future Regulation*, 4 UNIVERSITY OF PENNSYLVANIA JOURNAL OF LAW AND PUBLIC AFFAIRS 82, 84 (2018).

5. *See* Paul Dean & Henry Clack, *Autonomous Shipping and Maritime Law, in* NEW TECHNOLOGIES, ARTIFICIAL INTELLIGENCE AND SHIPPING LAW IN THE 21ST CENTURY 67, 67 (Baris Soyer & Andrew Tettenborn eds., 2020) ("Once mere science fiction, autonomous ships . . . will soon become part of commercial reality.").

6. Aldo Chircop, *Maritime Autonomous Surface Ships in International Law: New Challenges for the Regulation of International Navigation and Shipping, in* COOPERATION AND ENGAGEMENT IN THE ASIA-PACIFIC REGION 18, 18–19 (Myron H. Nordquist, John Norton Moore & Ronan Long eds., 2020).

7. *Rolls-Royce and Finferries Demonstrate World's First Fully Autonomous Ferry*, ROLLS-ROYCE (Dec. 3, 2018), https://www.rolls-royce.com/media/press-releases/2018/03-12-2018-rr-and-finferries-demonstrate-worlds-first-fully-autonomous-ferry.aspx.

8. *See* Danielle Sullivan Kaminski, *Who's to Blame When no one is Manning the Ship?*, LAW360 (Oct. 4, 2016), https://www.law360.com/articles/847478.

9. *See* James Kraska, *The Law of Unmanned Naval Systems in War and Peace*, 5 THE JOURNAL OF OCEAN TECHNOLOGY 44, 44 (2010) ("Unmanned systems are becoming ubiquitous in the oceans, and naval forces throughout the world are primary operators of unmanned aerial vehicles (UAVs), unmanned surface vessels (USVs) and unmanned underwater vehicles (UUVs)."); *see also* CRAIG ALLEN, INTERNATIONAL LAW FOR SEAGOING OFFICERS 278 (6th ed. 2014) ("[U]nmanned vehicle technology and automated networks will be an important basis of the future Navy. The littoral combat ship was, in fact, designed to carry and work with a variety of unmanned systems. Seagoing officers are therefore increasingly likely to

has spearheaded this effort, issuing Master Plans for Unmanned Underwater Vehicles (UUV) and Unmanned Surface Vehicles (USV) in 2004 and 2007, respectively.[10] In just over a decade, these plans have been implemented to a remarkable degree. For example, the U.S. Navy's first operational UUV, the "Remote Mine-hunting System," was deployed during Operation Iraqi Freedom for minesweeping of the Khwar Abd Allah River and the Iraqi port of Umm Qasr.[11] In 2018, the Defense Advanced Research Projects Agency (DARPA) completed the *Sea Hunter* USV, a 130-foot vessel "capable of operating autonomously or semi-autonomously for up to seventy days without resupply."[12]

Similarly, the Coast Guard has integrated unmanned and autonomous technology at sea. Its 418-foot national security cutter is now equipped with a ScanEagle aerial drone,[13] and in February 2020, a contract was awarded to Spatial Integrated Systems Inc. to develop a USV system to increase maritime domain awareness in the remote Pacific Ocean.[14] In addition to these naval applications, unmanned and autonomous vehicles are also used for a host of mixed naval, scientific, and commercial purposes, including seafloor mapping, hydrography, marine scientific research, and mineral prospecting, among others.[15]

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operate with unmanned aerial and marine systems and must be alert to the potential legal issues posed by their use.").

10. Craig Allen, *Determining the Legal Status of Unmanned Maritime Vehicles: Formalism v. Functionalism*, 49 JOURNAL OF MARITIME LAW AND COMMERCE 477, 478 (2018).

11. Kraska, *supra* note 9, at 46.

12. Christopher C. Swain, *Towards Greater Certainty for Unmanned Navigation: A Recommended United States Military Perspective on Application of the "Rules of the Road" to Unmanned Maritime Systems*, 3 GEORGETOWN LAW AND TECHNOLOGY REVIEW 119, 129 (2018); *see also* Allen, *supra* note 10, at 478.

13. *See* Michael R. Sinclair, *"A Few Armed [Drones], Judiciously Stationed, Might at a Small Expense be Made Useful Sentinels of the Law": The Sufficiency of Existing Law as Applied to the U.S. Coast Guard's Inevitable Use of Unmanned Aircraft Capable of Employing Use of Force in the Maritime Counter-Drug Mission*, 18 LOYOLA MARITIME LAW JOURNAL 1, 23 (2019).

14. *Spatial Integrated Systems (SIS) Wins US Coast Guard Maritime Domain Awareness Pilot Study Contract*, YAHOO! FINANCE (Feb. 25, 2020), https://finance.yahoo.com/news/spatial-integrated-systems-sis-wins-130000100.html.

15. Eric Van Hooydonk, *The Law of Unmanned Merchant Shipping – an Exploration*, 20 JOURNAL OF INTERNATIONAL MARITIME LAW 403 (2014).

B. Opportunities and Challenges

Autonomous vessel technology opens up new possibilities in personal and digital maritime mobility and has the potential to deliver a host of economic, environmental, and public benefits.[16] But it also presents exceptionally difficult questions: Is the existing international order of the seas equipped to deal with autonomous vessel operations?[17] Can autonomous vessel technology fully discharge the duties of an experienced watch-stander at sea?[18] Do the potentially devastating implications of an autonomous vessel cyberattack outweigh the anticipated benefits of autonomous operations?[19] While these questions remain largely unanswered, the International Maritime Organization (IMO) has recently undertaken a "regulatory scoping exercise" for the use of MASS to tackle these and other issues related to unmanned and autonomous ships.[20] Among other tasks, the IMO will determine which existing IMO instruments might preclude MASS operations, which instruments do not preclude MASS operations but may need to be amended or clarified, and which instruments are inapplicable to MASS operations.[21]

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16. Carp, *supra* note 4, at 85. ("[A]utonomous vehicles promise to deliver significant social, economic, and environmental benefits to both consumers and businesses.").

17. *See* Natalie Klein, *Maritime Autonomous Surface Vehicles within the International Law Framework to Enhance Maritime Security*, 95 INTERNATIONAL LAW STUDIES 244, 244 (2019) ("The use of maritime autonomous vehicles (MAVs) . . . raises challenging questions about how these crafts fit within existing ocean governance.").

18. *See* Van Hooydonk, *supra* note 15, at 405.

19. *See* Erich D. Grome, *Spectres of the Sea: The United States Navy's Autonomous Ghost Fleet, its Capabilities and Impacts, and the Legal Ethical Issues that Surround*, 49 JOURNAL OF MARITIME LAW AND COMMERCE 31, 50 (2018) ("[A] cyberattack could involve disrupting the communications between the vessels and their human monitors, leaving the ships unable to continue their previously assigned mission ….").

20. *See Autonomous Shipping*, IMO, http://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx (last visited Jan. 21, 2021). In light of the COVID-19 pandemic, the work of IMO has been moved to a virtual format. Due to the inherent limitations of virtual technologies, substantive work on the MASS regulatory scoping exercise has generally been deferred to later sessions; *see, e.g.*, Provisional Agenda, IMO Doc. MSC 102/1/Rev.1 (Sept. 23, 2020) (noting that agenda item 5, Regulatory scoping exercise for the use of Maritime Autonomous Surface Ships (MASS), has been postponed to the 103rd session of the Maritime Safety Committee). As such, it is very unlikely that the IMO's regulatory scoping exercise for the use of MASS will be completed in 2021, as originally planned.

21. *Id.*; *see also* Aldo Chircop, *Testing International Legal Regimes: The Advent of Automated Commercial Vessels*, 60 GERMAN YEARBOOK OF INTERNATIONAL LAW 1, 6 (2018)).

The scope and ambition of the IMO's undertaking are made manifest by the exponential growth of commercial, naval, and science-oriented unmanned and autonomous vessels discussed above. In contrast to the IMO's holistic review of MASS operations across the full panoply of maritime instruments under its purview, this article will chart a narrower course to examine the implications, opportunities, and challenges of autonomous vessels in three core Coast Guard mission areas of enduring significance to commercial and naval operators alike: (1) search and rescue, (2) maritime counterdrug operations and (3) navigational safety.

II. SEARCH AND RESCUE

The duty to render assistance to those in peril at sea—a "fundamental tenet of maritime law"[22]—is deeply embedded in the nautical tradition.[23] That tradition has evolved into legal duties codified in international conventions and domestic laws, which have formalized and strengthened the global search and rescue (SAR) system.[24] The relevant international provisions are found in Article 98(1) of the United Nations Convention on the Law of the Sea (UNCLOS)[25] and Chapter V, Regulation 33, of the International Convention for the Safety of Life at Sea (SOLAS).[26] Relatedly, the International Convention on Maritime Search and Rescue[27] provides an international framework by which coastal States cooperate in the implementation of the global SAR system.[28] These instruments are the lodestar for the Coast Guard's statutory duty to "perform any and all acts necessary to rescue and aid persons and protect and save property . . . on and under the high seas and on and under

22. Paul W. Pritchett, *Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology*, 40 TULANE MARITIME LAW JOURNAL 197, 208 (2015).

23. *See, e.g.*, Rick Button, *International Law and Search and Rescue*, *in* INTERNATIONAL LAW IN INTERNATIONAL STRAITS AND CURRENT MARITIME SECURITY CHALLENGES 101, 102 (Jorg Schildknecht, Rebecca Dickey, Martin Fink & Lisa Ferris eds., 2018) ("The search for and rescue of persons in distress is a centuries-old, time-honored tradition.").

24. *Id.* at 111.

25. United Nations Convention on the Law of the Sea art. 98(1), Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS].

26. International Convention for the Safety of Life at Sea ch. V, regulation 33, Nov. 1, 1974, 1184 U.N.T.S. 3 [hereinafter SOLAS].

27. International Convention on Maritime Search and Rescue, Apr. 27, 1979, 1405 U.N.T.S. 97.

28. Button, *supra* note 23, at 103.

water over which the United States has jurisdiction."[29] Collectively, the foundational SAR duty expressed in these instruments is to render assistance "to any person found at sea in danger of being lost."[30]

The framing of this duty merits additional discussion. The duty to render assistance under UNCLOS Article 98 is addressed to the *flag State*, which in turn "shall require the *master* of a ship flying its flag" to render assistance to any person in peril at sea, to the extent such assistance can be rendered without serious danger to the ship, crew, or passengers onboard.[31] Flag States, many of whom are parties to UNCLOS or regard Article 98 as reflective of customary international law, must therefore determine how to require a "master" to render assistance where no mariner is physically aboard.

While Article 98 is addressed to the flag State, in practice the rescue duty falls upon the master of the vessel.[32] For it is the master that is charged to render assistance to those in danger and to "proceed with all possible speed to the rescue of persons in distress."[33] This is as it should be. Indeed, it is the master at sea that heretofore has been the "eyes and ears of the global SAR system."[34] This duty applies in like manner to commanding officers of warships of the U.S. Navy and Coast Guard.[35] This conclusion leads ineluctably to the pivotal question of who, if anyone, is the "master" of a MASS? And if there is no "master" of a MASS, can the legal duty to render assistance—the thrust of which falls upon the master—continue to exist?[36]

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29. 14 U.S.C. § 88; *see also* Sinclair, *supra* note 13, at 9.

30. ALLEN, *supra* note 9, at 168.

31. UNCLOS, *supra* note 25, art. 98 (emphasis added); *see also* ALLEN, *supra* note 9, at 168; Button, *supra* note 23, at 112.

32. *See* Klein, *supra* note 17, at 265 ("Under UNCLOS and the SOLAS Convention, this obligation rests with the master of the vessel."); *see also* Pritchett, *supra* note 22, at 208 ("As we can see from the various formulations of the duty to rescue, all place the obligation squarely on the master of the vessel."); Allen, *supra* note 10, at 490 ("The master . . . has a duty to come to the aid of mariners in distress.").

33. UNCLOS, 25 note 25, art. 98(1)(b).

34. Button, *supra* note 23, at 111.

35. *See* THE COMMANDER'S HANDBOOK ON THE LAW OF THE NAVAL OPERATIONS 3-1–3-2, NWP 1-14M/MCTP 11-10B/COMDTPUB P5800.7A (2017), https://usnwc.libguides.com/ld.php?content_id=38386466 [hereinafter COMMANDER'S HANDBOOK].

36. *See* Pritchett, *supra* note 22, at 208; *see also* Klein, *supra* note 17, at 265.

A. Defining the Master, Conceptualizing the Duty

As autonomous vessel technology has progressed, a growing body of scholarship has sought to address the question of who, if anyone, is the master of a MASS?[37] These inquiries have yielded no definitive answers. The difficulty can be attributed in part to the sheer dissonance resulting from the introduction of autonomous technology into a realm that has vested ultimate responsibility for vessel and crew in a present ship's master.[38] Being present aboard—indeed, dutybound to remain aboard even under dire circumstances—has to date been the very essence of command at sea.[39] Moreover, the mature framework of international conventions and domestic legal obligations that reinforce the duty to render assistance were "designed for conventional ships controlled by a master, officers and crew."[40]

The "master" of a vessel is defined internationally as "the person having command of a ship."[41] Whether a person can be said to have "command" of a ship requires an analysis of the degree of autonomy with which a given ship is operating. Accordingly, the IMO's definition of MASS for purposes of its regulatory scoping exercise—"a ship which, *to a varying degree*, can operate independent of human interaction"[42]—anticipates a spectrum of autonomy. The first degree of autonomy, a "ship with automated processes

37. *See, e.g.*, Allen, *supra* note 10, at 489 ("Is the shoreside operator of a remotely controlled [unmanned maritime vehicle] that craft's 'master?' Is the programmer (or program team) of a fully autonomous [unmanned maritime vehicle] the craft's 'master?'"); Pritchett, *supra* note 22, at 208 ("[W]ho is the master of a [unmanned surface vehicle]?").

38. *See* Henrik Ringbom, *Regulating Autonomous Ships—Concepts, Challenges, and Precedents*, 50 OCEAN DEVELOPMENT AND INTERNATIONAL LAW 141, 154 (2019) ("Autonomous navigation . . . represents a much more fundamental challenge to the current regulatory environment. Autonomous navigation challenges the authority and role of crew members ….").

39. *See, e.g.*, *Captain's Uncourageous: Abandoning Ship Long Seen as a Crime*, NPR (Apr. 18, 2014), https://www.npr.org/2014/04/18/304541866/captains-uncourageous-abandoning-ship-long-seen-as-a-crime ("In the U.S., case law indicates that a ship's master must be the last person to leave [a sinking ship] and make all reasonable efforts to save everyone and everything on it.").

40. *See* Hooydonk, *supra* note 15, at 409 ("[T]he provisions of [UNCLOS] about the nationality of ships are designed for conventional ships controlled by a master, officers and a crew.").

41. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, ch. 1, reg. I(c), July 7, 1978, 1361 U.N.T.S 2.

42. *See* Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS), Report of the Working Group annex 1, IMO Doc. MSC99/WP.9 (May 23,

and decision support," presents an established and uncontroversial mode of operation in which seafarers aboard are assisted by electronic tools.[43] These tools include, *inter alia*, autopilot, pre-programmed navigational track lines, or dynamic positioning systems that can be used for precision placement of aids to navigation, such as buoys.[44] In this mode, the master is unquestionably still in "command" and subject to the duty to render assistance.

The second degree of autonomy, a remotely controlled ship with seafarers onboard, yields a similar conclusion. Namely, with seafarers still aboard, there is no difficulty in concluding that a physically present "master," empowered to manually override remote operation, remains in command of the ship. Moreover, until autonomous vessel technology can better anticipate and respond to the virtually unlimited fact patterns presented to a master at sea, such an override capability will likely remain an operational necessity.[45] The duty to render assistance, whether articulated as a "hybrid" duty of the present master and the remote operator,[46] or the non-delegable duty of the present master, persists unabated in the second degree of autonomy.

The third degree of autonomy, a remotely controlled ship without seafarers on board, presents a more nuanced analysis. Can it fairly be argued that a remote operator at a computer screen or shoreside command center,

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2018) [hereinafter IMO Doc. MSC99/WP.9] (emphasis added); *see also* Chircop, *supra* note 6, at 19.

43. *See* Report of the Maritime Safety Committee on its One Hundredth Session annex 2, IMO Doc. MSC100/20/Add.1 (Dec. 12, 2018). The IMO's regulatory scoping exercise for MASS utilizes four "degrees of autonomy" for its analysis: (1) Ship with automated processes and decision support; (2) remotely controlled ship with seafarers on board; (3) remotely controlled ship without seafarers on board; and (4) fully autonomous ship.

44. *See* Ringbom, *supra* note 38, at 150.

45. *See id.* at 154 ("The prospect of a fully developed autonomy, in which a ship undertakes an entire voyage totally without human supervision or involvement, is hardly realistic in the short term. For the forseeable future, at least, there will normally be some crew members available to assume control of—and responsibility for—the ships operation, either on board or remotely."); s*ee also* Scott N. MacKinnon, Yemao Man, Monica Lundh & Thomas Porathe, *Command and Control of Unmanned Vessels: Keeping Shore Based Operators In-The-Loop* (Paper presented at the NAV 2015 18th International Conference on Ships and Shipping Research), https://www.researchgate.net/publication/281934219_Command_and_Control_of_Unmanned_Vessels_Keep_Shore_Based_Operators_In-The-Loop ("Humans must be retained within a system that is primarily controlled by intelligent computers in order to handle unexpected events not anticipated by the designers of the automated system.").

46. *See* Pritchett, *supra* note 22, at 208–9.

"navigating" the crewless ship thousands of miles away, is that ship's "master?"[47] Some commentators say it can. Professor Klein has suggested that where a crewless MASS is remotely controlled, the remote operator could serve as the "functional equivalent to the master," to whom the duty to rescue would attach.[48] Pritchett's oft-cited analysis echoes this view:

> The remote operator of the USV is in control of the vessel just as much as a person physically present aboard it would be. This person determines the speed at which the USV operates, chooses where to steer it, and can decide whether or not the vessel will stop and assist others in need. As such, the remote operator is almost certain to be "in charge" of the USV . . . and therefore would owe a duty to rescue.[49]

Pritchett's analysis of what it means to be "in charge" or "in command" finds support in the Convention on the International Regulations for Preventing Collisions at Sea (COLREGS), Rule 3 of which defines as "vessel not under command" as one "which through some exceptional circumstance is unable to maneuver as required by these Rules."[50] There is nothing inherent in the remote operation of a crewless MASS that would suggest it is unable to maneuver as required by the COLREGS.[51] A crewless but fully maneuverable remotely operated MASS might therefore be, *ipso facto*, under the "command" of its remotely operating "master." But not all commentators are so convinced. For example, Professor Van Hooydonk has observed that "the task of a shore-based vessel controller is not entirely similar to that of a ship's master," and "one cannot escape the feeling that such an interpretation [of functional equivalence] is too extensive and slips into interpretation *per analogiam*, something that tends to be frowned upon in international law."[52]

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47. *See* Allen, *supra* note 10, at 489 ("Is the shoreside operator of a remotely-controlled autonomous [unmanned maritime vehicle] the craft's 'master?'").

48. Klein, *supra* note 17, at 265.

49. Pritchett, *supra* note 22, at 209.

50. Convention on the International Regulations for Preventing Collisions at Sea r. 3(f), Oct. 20, 1972, 28 U.N.T.S 3459 [hereinafter COLREGS].

51. Whether a MASS can otherwise comply with the various COLREGs rules is taken up in Part II.C *infra*.

52. Van Hooydonk, *supra* note 15, at 410.

Whether a remote operator can be treated as the functional equivalent of a ship's master is a profoundly difficult[53] yet critically important question in refining the international law and regulations associated with autonomous vessel operations. Indeed, the September 2019 IMO Report of the Intersessional Working Group on MASS identified clarification of the definition of "master" and "remote operator" as fundamental issues to be resolved in multiple IMO instruments, including the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)[54] and the SOLAS Convention.[55] While it will take time to resolve the precise contours of these thorny legal and policy questions, it is not too soon to conclude that the duty to render assistance does attach to a remote operator. As an initial matter, the humanitarian principles that undergird the duty to render assistance counsel a bias toward action in favor of lifesaving at sea,[56] irrespective of whether it is orchestrated by a physical master or a remote operator. Moreover, the robust and overlapping mechanisms of the global SAR system—imposing obligations to render assistance on commercial, recreational, and military vessel masters alike[57]—augur in favor of applying a corresponding duty upon a MASS remote operator.[58]

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53. *See* Pritchett, *supra* note 22, at 208 ("Unfortunately, these are not easy questions to answer.").

54. *See* Report of the Intersessional Working Group on Maritime Autonomous Surface Ships, IMO Doc. MSC 102/5/1, ¶¶ 3.6–3.7 (Oct. 10, 2019) ("[I]n particular, the definition of master would need to clarified and a definition of remote operator might need to be established.").

55. *See id.* ¶ 3.25 ("The Group noted that the definition of master, crew and/or responsible person could be considered as a common potential gap and theme.").

56. *See* Resolution, Guidelines on the Treatment of Persons Rescued at Sea ¶ 3.1, IMO Doc. MSC 167(78) (May 20, 2004) ("All persons in distress at sea should be assisted without delay."); *see also id.* ¶ 5.1 ("Shipmasters have certain duties that must be carried out in order to provide for safety of life at sea, preserve the integrity of global SAR services of which they are a part, and to comply with humanitarian and legal obligations.").

57. *See* COMMANDER'S HANDBOOK, *supra* note 35, at 3-1 ("Customary international law has long recognized the affirmative obligation of mariners to render assistance to persons in distress."); *see also* Button, *supra* note 23, at 115–116 ("It also can be argued that, with this historical and universal principle enshrined in the SOLAS Convention, the Salvage Convention, and UNCLOS, the CO's duty to render assistance to persons in distress constitutes customary international law.").

58. *See* Berg v. Chevron, 759 F.2d 1425, 1429 (9th Cir. 1985) ("The maritime rescue doctrine has developed as an encouragement to life saving attempts.").

The fourth and final degree of autonomy is fully autonomous. This describes a ship whose operating system "is able to make decisions and determine actions by itself."[59] Such a ship seemingly obviates the role of a human "master," as there is no such person in command.[60] Thus, the fully autonomous vessel stands even further than the "remote operator" from traditional conceptions of a ship's master. Still, Professor Allen, one of the principal law of the sea commentators to address autonomous vessel issues, has queried whether a "programmer (or program team) of a fully autonomous" vessel might be considered its "master."[61] Others have suggested that the autonomous vessel itself, as the entity "in charge" of its movement and operation, might be considered its *own* master, subject to rescue obligations.[62] These are not hypothetical ponderings to nudge soft spots in existing norms. These are technological realities that may well redefine them. Indeed, advances in machine learning, a branch of artificial intelligence, have yielded computer programs that independently improve system performance over time through learned experience.[63] As this iterative process of machine learning advances, the fully autonomous ship may become increasingly independent of its incipient programming—more fully "in command." The inquiry then becomes if, and when, a fully autonomous ship has so improved its understanding of a duty to render assistance and capacity to discharge that duty, that it becomes obligated to do so. While fully autonomous technology has not yet matured to the degree necessary to establish such a duty, the extant obligations to render assistance at sea may yet be reshaped in the shadow of the autonomous revolution.[64]

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59. IMO Doc. MSC99/WP.9, *supra* note 42, annex 1.

60. *See* Pritchett, *supra* note 22, at 209 ("[W]hen a USV operates autonomously, i.e., a computer has command of the vessel, there does not appear to be any person who can directly hold the status of master by definition."); *see also* Dean & Clack, *supra* note 5, at 74 ("[I]t is arguable that, in certain circumstances and depending on the degree of autonomy exhibited by the MASS, that the MASS has no master.").

61. *See* Allen, *supra* note 10, at 489.

62. *See* Pritchett, *supra* note 22, at 209.

63. *See* Harry Surden, *Machine Learning and Law*, 89 WASHINGTON LAW REVIEW 87, 88 (2014).

64. *See supra* notes 1–8 and accompanying text.

B. Benefits and Challenges: SAR and Autonomous Ships

The above analysis concludes that a duty to render assistance at sea attaches to a ship with automated processes and decision support (degree one autonomy), a remotely controlled ship with crew members on board (degree two autonomy), and a remotely controlled ship without a crew (degree three autonomy). It further suggests that fully autonomous ships (degree four autonomy) may eventually progress to such a degree that an affirmative duty ripens for such ships to render assistance. Given the onboard presence of a physical crew in degrees one and two, the SAR benefits and limitations of these autonomous modes closely track those of existing SAR capabilities. This section will thus focus on the unique SAR advantages and challenges presented by ships operating in degree three and four autonomy.

1. SAR Benefits of Autonomous Ships

The circumstances that occasion the need for rescue at sea often present unique dangers to those conducting SAR operations. In light of these inherent dangers, "the duty to provide assistance [at sea] is a qualified one."[65] Namely, a shipmaster need not place his or her ship, crew, or passengers in undue danger in order to effect the rescue.[66] The incorporation of degree three and four MASS as a SAR force multiplier has the potential to greatly reduce the dangers that would otherwise face humans battling violent seas, punishing weather, and limited visibility while conducting maritime SAR operations.[67] Indeed, MASS may provide a two-prong benefit of safeguarding maritime first responders and increasing the resilience of SAR operations that would otherwise be limited or completely suspended by adverse conditions.[68]

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65. Dean & Clack, *supra* note 5, at 74.

66. *See* SOLAS, *supra* note 26, ch. V, regulation 33; *see also* ALLEN, *supra* note 9, at 168; Button, *supra* note 23, at 113.

67. *See* Anibal Matos et al., *Unmanned Maritime Systems for Search and Rescue*, *in* SEARCH AND RESCUE ROBOTICS: FROM THEORY TO PRACTICE 77, 77 (2017) ("[Maritime search and rescue] teams are often forced to adapt, or even to suspend their operations due to external factors and conditions, such as lack of visibility or atmospheric and/or maritime adverse conditions.").

68. *See* Klein, *supra* note 17, at 246 ("[B]ecause they reduce risk to human life, unmanned systems are becoming the preferred alternative for dull, dirty or dangerous missions.")

Autonomous ships may also enhance maritime domain awareness and detection capability as compared to manned rescue teams, particularly in situations of reduced visibility, through advanced suites of sensor technology, including infrared radar and thermal scanners.[69] These cutting-edge shipboard sensors, which are being developed in parallel with the "advent of remotely controlled and MASS," aim to "extend the functionality of existing systems" and "provide entirely new abilities that have not been possible in the past."[70] Further, sophisticated sensor and communications packages may open new horizons for autonomous SAR cooperation between MASS and unmanned aerial vehicles (UAV). UAVs have already proven highly effective for the Coast Guard[71] and the U.S. Navy,[72] and are becoming increasingly prevalent in their operations.[73] A number of commentators have suggested that joint UAV-MASS operations will enhance the operating range and detection capabilities of the MASS, making MASS a more resilient, robust SAR asset.[74] Maturing research on the SAR applications of "swarm intelligence" technology, in which "swarms of UAVs build upon cooperative behavior-

(quoting Raul (Pete) Pedrozo, Employment of Marine Unmanned Vehicles in the South China Sea 1 (unpublished manuscript)).

69. *See* Matos et al., *supra* note 67, at 80 (describing an unmanned surface vehicle equipped with a "sensor suite" including radar, laser scanner, weather station, daylight camera, and thermal camera); *see also Unmanned Vehicles Could Aid Search and Rescue*, THE MARITIME EXECUTIVE (Dec. 16, 2016), https://www.maritime-executive.com/editorials/unmanned-vehicles-could-aid-search-and-rescue.

70. R. Glenn Wright, *Intelligent Autonomous Ship Navigation Using Multi-Sensor Modalities*, 13 INTERNATIONAL JOURNAL ON MARINE NAVIGATION AND SAFETY OF SEA TRANSPORTATION 503, 505 (2019).

71. *See* Sinclair, *supra* note 13, at 22–23.

72. *See, e.g.*, Grome, *supra* note 19, at 46 ("Recently introducing the newest generation in UAV technology, DARPA announced the arrival of the Lightning Strike drone, equipped with new propulsion systems that increase the unmanned aircraft's speed, maneuverability, and range . . .").

73. *See* Kraska, *supra* note 9, at 61.

74. *See, e.g.*, Wright, *supra* note 70, at 505 ("Supplemental [MASS] capability at and above sea level can be achieved using Unmanned Aerial Vehicles (UAVs) equipped with similar sensors to extend the vessel's vision."); *see also Unmanned Vehicles Could Aid Search and Rescue*, *supra* note 69 ("Operating with other assets, such as an aircraft or UAV . . . may allow the unmanned marine vehicle a greater view of the area, to aid in rescue or avoid dangers. Operating with a mesh of UAVs could also . . . extend[ ] its operating area.").

based intelligence to efficiently locate one or multiple targets," further buttresses the promise and potency of joint UAV-MASS operations.[75]

2. SAR Challenges of Autonomous Ships

While MASS technology has tremendous potential to enhance SAR capabilities, MASS have a number of operational limitations that underscore the ways in which autonomous systems remain an imperfect substitute for crewed rescue platforms.[76] The most glaring limitation of MASS is that they lack human rescuers to physically extract imperiled seafarers that may be immobilized by injury or exposure. Even for the Coast Guard's elite Aviation Survival Technicians (colloquially, "rescue swimmers"), who are specially trained "to save lives in the harshest conditions imaginable,"[77] such rescues present extraordinary challenges. For a ship with no human crew, such rescues may be well-nigh impossible.[78]

For a MASS to be operationally effective, it must be able to maintain the desired course or, if necessary, a fixed position.[79] Researchers have found that factors including "large windage areas" of MASS, their relative weight, heavy currents, and rapid environmental changes can present substantial problems for a MASS in maintaining course or position.[80] Of course, gale-

75. *See, e.g.*, Ross D. Arnold, Hiroyuki Yamaguchi & Toshiyuki Tanaka, *Search and Rescue With Autonomous Flying Robots Through Behavior-based Cooperative Intelligence*, 3 JOURNAL OF INTERNATIONAL HUMANITARIAN ACTION 1, 3 (2018).

76. *See* Michael N. Schmitt & David S. Goddard, I*nternational Law and the Military Use of Unmanned Maritime Systems*, 98 INTERNATIONAL REVIEW OF THE RED CROSS 567, 569 ("[Unmanned maritime systems] may have design limitations that render them ineffective in certain circumstances to which the crews of manned systems might be better able to react.").

77. *See* Tristram Korten, *The Waterlogged Hell of Becoming a Coast Guard Rescue Swimmer*, GQ (Oct. 27, 2016), https://www.gq.com/story/how-to-become-coast-guard-rescue-swimmer-into-the-storm.

78. Klein, *supra* note 17, at 265 ("[P]ractical issues may emerge in terms of the capabilities of a [maritime autonomous vehicle] to take rescue individuals onboard . . .."); *see also Unmanned Vehicles Could Aid Search and Rescue*, *supra* note 69 ("The primary technical hurdle may be how to rescue people who are incapacitated and cannot help themselves.").

79. Edoardo I. Sarda, Huajin Qu, Ivan R. Bertaska & Karl D. von Ellenrieder, *Station-keeping Control of an Unmanned Surface Vehicle Exposed to Current and Wind Disturbances*, 12 OCEAN ENGINEERING 305, 305 (2016) ("To be effective, a [unmanned surface vehicle] needs to be capable of autonomously performing a variety of distinct maneuvers, with trajectory tracking and station-keeping being essential in their roles.").

80. *Id.* at 305–6.

force winds, strong currents, and rapid environmental changes are often the predicate for initiating maritime SAR. Given these operational limitations, it is reasonable to conclude that a MASS may be unable to reach imperiled seafarers or remain on station to provide SAR assistance in extreme weather or sea states. These limitations tend to weaken the argument that unmanned maritime systems are a more "persistent" asset than their manned counterparts.[81] Moreover, even when a MASS can reach a distressed mariner, it will likely have a limited capacity to provide emergency shelter or medical support.[82] This is particularly true for large-scale rescue operations, occasioned by events such as transoceanic flight crashes and maritime refugee movements, in which large numbers of people must be rescued at once.[83]

But these operational limitations do not imply that MASS cannot play a pivotal role in the future of maritime SAR.[84] As described above, MASS equipped with advanced sensors may shorten the time it takes to locate distressed mariners over a vast search area, particularly when working in tandem with a UAV. Further, while a MASS may be unable to personally embark mariners, it may be equipped to deploy a life raft or other temporary floatation device.[85] Similarly, a MASS that can supply even modest quantities of drinking water, food, and emergency medical supplies, such as insulin and gauze, may provide a lifesaving "bridge" until manned rescue forces arrive. These benefits lend credence to the recent, pithy observation that "to a person in the water, the unmanned maritime vehicle would . . . be a massive improvement over nothing."[86] They also suggest that remote controlled and fully autonomous MASS systems will play an enduring and increasingly important role in the conduct of maritime SAR operations.

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81. *Cf.* John Yoo, *Embracing the Machines: Rationalist War and New Weapons Technologies*, 105 CALIFORNIA LAW REVIEW 443, 454 (2017) ("By being able to survive extensive damage, [unmanned naval systems] would be more 'persistent' and could operate in a wider variety of difficult conditions.").

82. Klein, *supra* note 17, at 265; *see also* Pritchett, *supra* note 22, at 209.

83. Thomas Gorgol & Richard Button, *Understanding the Challenge: Mass Rescue Operations at Sea*, *in* COOPERATION AND ENGAGEMENT IN THE ASIA-PACIFIC REGION, *supra* note 6, at 356, 357.

84. Indeed, manned SAR assets experience many of these same challenges.

85. *Unmanned Vehicles Could Aid Search and Rescue*, *supra* note 69.

86. *Id.*

III. MARITIME COUNTERDRUG OPERATIONS

The maritime domain has provided an abundance of food, energy, and trade benefits to the world.[87] But it has also been a locus of activity for transnational criminal and terrorist organizations that seek to exploit *mare liberum* for ill-gotten gains.[88] Maritime drug trafficking, orchestrated by a web of sophisticated and well-financed criminal networks,[89] has been one of the most persistent and vexing examples of such illicit activity.[90] Indeed, "international trade in illegal drugs ranks third in value among global commodity flows," trailing only oil and agriculture.[91] The world's oceans—particularly the Western Hemisphere Transit Zone—have become the international highway for delivering many of these illegal drugs to market.[92] Brian Wilson, Deputy Director of the U.S. Department of Homeland Security's Global Maritime Operational Threat Response Coordination Center, observed that "transnational criminal organizations operating in South America recognize the value of the oceans as critical routes, given the anonymity a ship enjoys over large,

87. *See Oceans and the Law of the Sea*, UNITED NATIONS, https://www.un.org/en/sections/issues-depth/oceans-and-law-sea/index.html (last visited Jan. 21, 2021) ("The ocean has always been an important source of food for the life it helped generate, and from earliest recorded history it has also served trade and commerce, adventure and discovery.").

88. *See* NATALIE KLEIN, MARITIME SECURITY AND THE LAW OF THE SEA 130 (2011) ("The situation has only worsened post-September 11, as drug trafficking at sea has evolved into a major transnational organized criminal endeavor and terrorist groups are reported to use drug trafficking as a source of revenue.").

89. ALLEN, *supra* note 9, at 237 ("[T]he threat posed by [maritime] drug trafficking and related crimes is transnational, well-organized, and well-financed . . ..").

90. *See generally* DOUGLAS GUILFOYLE, SHIPPING INTERDICTION AND THE LAW OF THE SEA 95 (2009) ("At-sea [drug] interdictions are logistically complex, potentially dangerous and often very expensive. Only a limited number of states have the resources and trained personnel to conduct them.").

91. JAMES KRASKA & RAUL PEDROZO, INTERNATIONAL MARITIME SECURITY LAW 519 (2013)

92. Aaron J. Casavant, *In Defense of the U.S. Maritime Drug Law Enforcement Act*, 8 HARVARD NATIONAL SECURITY LAW JOURNAL 191, 197 (2017) ("The Transit Zone is a seven square million-mile area between the countries in South America where illegal narcotics are produced and the delivery points along the coast of Central America and Mexico. It includes Central America, the Eastern Pacific Ocean, and the Western Caribbean Sea, which are regularly patrolled by the Department of Homeland Security), U.S. Coast Guard (USCG), and Department of Defense (DOD) air and surface assets.").

ungoverned stretches of space, the relative complexities in jurisdiction, and the limited capacity of most countries' coastal law enforcement."[93]

Much like the robust international legal and regulatory regime regarding maritime search and rescue, a mature multilateral treaty and U.S. domestic framework has been erected to confront maritime drug traffickers.[94] The cornerstone of the maritime counterdrug regime is found in Article 108 of UNCLOS,[95] which requires that all States "cooperate in the suppression of illicit drugs and psychotropic substances engaged in by ships on the high seas."[96] This obligation to cooperate in combating drug trafficking extends to the exclusive economic zone by operation of Article 58(2) of UNCLOS.[97]

The United Nations, particularly the U.N. Office on Drugs and Crime, has played a key role in developing the international maritime counterdrug framework. In fact, U.N. member States have concluded three conventions aimed at countering traffic in illegal narcotics at sea since 1961. While these conventions are "mutually supportive and complementary,"[98] the most recent and influential has been the 1988 UN Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances (Vienna Convention).[99] Collectively, these conventions provide the international machinery necessary to operationalize UNCLOS Article 108's obligation to cooperate in the suppression of illicit drugs at sea. The fulcrum of that implementation is found in Article 17 of the Vienna Convention,[100] which provides a mechanism for a party when it has "reasonable grounds to suspect that a vessel . . . flying

93. Brian Wilson, *Submersibles and Transnational Criminal Organizations*, 17 OCEAN AND COASTAL LAW JOURNAL 35, 39 (2011)

94. *See* James Kraska, *Broken Taillight at Sea: The Peacetime International Law of Visit, Board, Search, and Seizure*, 16 OCEAN AND COASTAL LAW JOURNAL 1, 11 (2010) ("Treaties to suppress international drug trafficking constitute some of the most mature maritime treaties designed to promote maritime security cooperation.").

95. KRASKA & PEDROZO, *supra* note 91, at 522.

96. UNCLOS, *supra* note 25, art. 108.

97. *Id.* art. 58(2) ("Articles 88 to 115 and other pertinent rules of international law apply to the exclusive economic zone in so far as they are not incompatible with this Part."); *see also* KRASKA & PEDROZO, *supra* note 91, at 522.

98. *See* ALLEN, *supra* note 9, at 238.

99. United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, Dec. 20, 1988, 1582 U.N.T.S. 164 [hereinafter 1988 Vienna Convention]. The two preceding conventions were the Single Convention on Narcotic Drugs, Mar. 30 1961, 520 U.N.T.S. 151, and the Convention on Psychotropic Substances, Feb. 21, 1971, 1019 U.N.T.S 175.

100. *See* KRASKA & PEDROZO, *supra* note 91, at 538–39.

the flag or displaying the marks of registry of another Party is engaged in illicit traffic," to notify the flag State, request confirmation of registry, and if confirmed request permission to board the suspect vessel.[101]

Most States are now party to the Vienna Convention. Indeed, it has come to represent an inflection point in global efforts to suppress illicit maritime drug flows.[102] However, States Parties have had to fill interstices and inefficiencies in its framework. For example, while the Article 17 process is a pathway for communications between governments to facilitate interdiction of suspect vessels, it can often be painfully slow.[103]

To remedy this problem, the United States has entered into thirty bilateral or regional agreements with countries in South America, Central America, the Caribbean, and West Africa. These agreements provide simplified, expedited procedures to facilitate verification of vessels registry, obtain permission to conduct boarding operations, and coordinate disposition of seized contraband.[104] The Coast Guard has complemented this robust network of international agreements with advanced enforcement capabilities, including the deployment of its elite Helicopter Interdiction Tactical Squadron, which employs airborne use of force to operationally disable and interdict non-compliant drug trafficking vessels at sea.[105] As the lead federal agency for U.S. drug interdiction on the high seas, the Coast Guard has achieved unprecedented operational milestones. To that end, in both Fiscal Year 2017 and Fiscal Year 2018 the Coast Guard seized over two hundred metric tons of cocaine at sea.[106]

The Coast Guard's maritime counterdrug framework, while robust, is a necessary—but not sufficient—tool to combat the maritime trafficking of illegal narcotics. Indeed, the Coast Guard's interdiction of 209.6 metric tons of cocaine at sea in 2018—a banner year by any measure—represented just 7 percent of the nearly three thousand metric tons of *known* cocaine flow

101. 1988 Vienna Convention, *supra* note 99, art. 17.3.

102. Casavant, *supra* note 92, at 205.

103. *Id.*

104. *Id.* at 205–6.

105. *See* Sinclair, *supra* note 13, at 3 ("Beginning in the late 1990s, the Coast Guard enjoyed significant success employing helicopter airborne use of force (AUF) to execute its counter-narcotics mission.").

106. *See* U.S. COAST GUARD, UNITED STATES COAST GUARD ANNUAL PERFORMANCE REPORT: FISCAL YEAR 2018, at 33 (2019), https://www.uscg.mil/Portals/0/documents/budget/FY%202018%20USCG%20APR%20Signed%206-12-19.pdf.

through the Western Hemisphere Transit Zone during that period.[107] This enforcement gap is attributable in part to the persistence of sophisticated, well-financed drug cartels that have proven adept at evading U.S. maritime law enforcement tactics.[108] Specifically, drug cartels have engaged in a decades-long process of "evolution and adaptation" to escape detection and interdiction at sea.[109] This process began in earnest with the acquisition of fishing or recreational vessels as drug carriage platforms, later refined by complex drug concealment tactics.[110] Traffickers then adopted lightweight, heavily powered speedboats ("go-fast" vessels) to reduce at-sea transit time.[111] With the advent of helicopter interdiction that proved effective at stopping such go-fast vessels,[112] drug traffickers again adapted their techniques through the introduction of "self-propelled semi-submersibles (SPSS)" or drug trafficking submarines, some of which are capable of storing up to fifteen tons of cocaine.[113] The SPSS, which combines substantial drug payload capacity, long-range transit, and a low or non-existent surface profile, is the *magnum opus* of four decades of increasingly sophisticated drug trafficking techniques.[114]

Even placing the nefarious diligence of drug cartels to one side, the vast expanse of the ocean remains the omnipresent, enduring challenge of maritime counterdrug operations.[115] At some seven million square miles (approx-

107. *Id.*

108. *See* Wilson, *supra* note 93, at 40 ("[S]mugglers are 'constantly adapting their techniques to counter U.S. law enforcement activities.'") (quoting U.S. DEPARTMENT OF HOMELAND SECURITY, OFFICE OF COUNTERNARCOTICS ENFORCEMENT FISCAL YEAR 2010 ANNUAL REPORT 8 (2011), http://www.dhs.gov/xlibrary/assets/cne-annualreport-2010.pdf).

109. *See* Casavant, *supra* note 92, at 199.

110. *Id.*

111. *Id.* at 200.

112. *See* U.S. COAST GUARD, *supra* note 106 and accompanying text.

113. *See* Casavant, *supra* note 92, at 200. *See also* Wilson, *supra* note 93, at 40 (noting that transnational criminal organizations invest approximately $2 million dollars to construct a single submersible vessel).

114. *See* Wilson, *supra* note 93, at 36 ("While transporting illicit cargo in the maritime domain is not new, the stealthy SPSS—a long-range vessel that is extremely difficult to identify and track—raised significant national security concerns.").

115. *See id.* at 39 n.2 ("Environmental factors unique to the maritime domain also contribute to maritime domain awareness challenges, such as the vastness of the oceans, the great length of shorelines, and the size of port areas that can provided concealment and

imately twice the size of the continental United States), the Western Hemisphere Transit Zone poses a tremendous challenge for law enforcement officials seeking to locate and interdict drug traffickers.[116] As noted by Coast Guard Captain Craig Wieschhorster, commanding officer of the 418-ft cutter *Stratton*, "[o]ur biggest frustration [in conducting maritime counterdrug operations] is the expanse of the operating area. It's the tyranny of distance. It's a big operating area out there, and we're literally running from case to case…."[117] Thus, maritime law enforcement officers face not only an adaptive, persistent foil in enterprising drug cartels but must also meet them on an exceedingly vast field of battle.

A. Counterdrug Benefits of Autonomous Vessels: Maritime Domain Awareness

Given the above challenges, this section explores the ways in which the benefits of autonomous vessel technology can substantially close the counterdrug enforcement gaps faced by maritime law enforcement officials. At the same time, it acknowledges lessons of history that suggest transnational criminal organizations will seize upon that same technology as an integral component of their drug trafficking arsenal. In this regard, autonomous vessel technology presents challenges that may indeed exacerbate illicit narcotics trafficking. Further, even where remote-controlled[118] or fully autonomous[119] drug trafficking vessels are successfully interdicted at sea, there are practical and jurisdictional challenges in prosecuting a remote, anonymous vessel operator.

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numerous access points to the land.") (quoting U.S. GOVERNMENT ACCOUNTABILITY OFFICE, PUB. NO. GAO-11-661, HOME DEFENSE: ACTIONS NEEDED TO IMPROVE DOD PLANNING AND COORDINATION FOR MARITIME OPERATIONS 7 (2011), http://www.gao.gov/products/GAO-11-661).

116. Office of National Drug Control Policy, *Transit Zone Operations*, OBAMAWHITEHOUSE.ARCHIVES.GOV, https://obamawhitehouse.archives.gov/ondcp/transit-zone-operations (last visited Jan. 21, 2021).

117. Dan Lamothe, *As Trump Presses for a Border Wall, There's a New Coast Guard Record for Drug Seizures at Sea*, WASHINGTON POST (Sept. 20, 2017), https://www.washingtonpost.com/news/checkpoint/wp/2017/09/20/as-trump-presses-for-a-border-wall-theres-a-new-coast-guard-record-for-drug-seizures-at-sea/; *see* Sinclair, *supra* note 13, at 23 n.87.

118. Degree three autonomy, according to the above taxonomy.

119. Degree four autonomy, according to the above taxonomy.

The maritime counterdrug mission is predicated upon the establishment and enhancement of maritime domain awareness (MDA). MDA is achieved through an "effective understanding of anything associated with the global maritime domain that could impact . . . security, safety, or [the] environment."[120] Given that over 70 percent of the earth's surface is covered by water,[121] the potential scope of *anything* associated with the global maritime domain is staggering. As suggested by Captain Wieschhorster and echoed by law of the sea scholars,[122] the greatest barrier to fostering effective MDA is the ocean's "tyranny of distance," which strains finite enforcement assets and cloaks illicit activity.[123] As such, leveraging autonomous vessel technology is exceptionally important for the maintenance and enhancement of MDA over the global maritime commons.

1. Greater Presence and Endurance

A clearly marked autonomous warship providing law enforcement presence at sea is an inherent deterrent to illicit activity. Indeed, while maritime law enforcement analysis tends to focus on *enforcement* capacity, the ability to discourage and deter illicit activity in the first instance is exceedingly valuable. As the U.S. Naval Postgraduate School's Center for Homeland Defense and Security has recently observed, maritime law enforcement

120. *See* U.S. DEPARTMENT OF HOMELAND SECURITY, NATIONAL STRATEGY FOR MARITIME SECURITY: NATIONAL PLAN TO ACHIEVE MARITIME DOMAIN AWARENESS, at ii (2005), https://www.dhs.gov/sites/default/files/publications/HSPD_MDAPlan_0.pdf; *see also* Amendments to the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual annex 11, IMO Doc. MSC.1/Circ. 1415 (May 25, 2012) (defining MDA as "the effective understanding of any activity associated with the maritime environment that could impact upon . . . security, safety, economy or [the] environment").

121. *How Much Water is There on, in, and Above the Earth?*, USGS, https://www.usgs.gov/special-topic/water-science-school/science/how-much-water-there-earth?qt-science_center_objects=0#qt-science_center_objects (last visited Jan. 21, 2021).

122. *See, e.g.*, Kraska, *supra* note 94, at 2 ("Leveraging the anonymity afforded by the vast tyranny of time and distance in the oceans, the resulting lawlessness destabilizes nations on every continent."); *see also* Wilson, *supra* note 93, at 46 ("Successful pursuit of submersibles requires multilateral collaboration because the operating environment is simply too large for any nation to address individually.").

123. *See* U.S. COAST GUARD, *supra* note 106, at 34 ("One reason for this decrease [in annual maritime drug interdictions] is likely due to the increasing expanse of the trafficking area and the transnational criminal organization's efforts to exploit that area.").

> force structure and utilization is, in part, based upon providing a certain amount of enforcement presence in a given area that is predicted to have a level of activity of interest to the federal government (ex: Bering Sea & fisheries, Straits of Florida & illegal immigration, southern Caribbean, Eastern Pacific & narcotics trafficking, Port state control inspectors w/in US ports, etc.) Part of the value of providing presence in each of these areas is quantified by violations detected and enforcement actions taken. However, *leaders believe that the greatest value of providing presence is in the illicit activity that is deterred.*[124]

While traditional warships can maintain such presence, the duration of that presence can be truncated or entirely terminated by any number of circumstances. For example, warships engaged in counterdrug operations might be diverted for urgent search and rescue missions or to conduct bunkering operations following a long-range interdiction. Autonomous vessels can fill that operational gap, ensuring a continuous enforcement presence. Similarly, as compared to traditional crewed warships, autonomous vessels have greater operational endurance as they do not need to return to port to obtain food supplies or crew rest. These attributes of autonomous vessels yield a more persistent at-sea presence.[125]

2. Enhanced Detection and Monitoring Capabilities

As described in the search and rescue context, autonomous vessels offer a host of enhanced detection and monitoring capabilities.[126] Indeed, a fleet of autonomous vessels equipped with sensor suites including radar, high definition video equipment, and forward-looking infrared thermal cameras would be particularly valuable in locating and tracking low- and no-profile drug trafficking platforms such as the SPSS.[127] By optimizing this sensor technology, "unmanned naval vessels could serve in a wide variety of . . . missions including surveillance, intelligence, and reconnaissance, both on the

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124. U.S. COAST GUARD, DETERRENCE AND THE UNITED STATES COAST GUARD: ENHANCING CURRENT PRACTICE WITH PERFORMANCE MEASURES 16 (2012), https://www.hsdl.org/?view&did=705407 (emphasis added).

125. *See* Schmitt & Goddard, *supra* note 76, at 570.

126. *See supra* notes 69–75 and accompanying text.

127. *See* Wilson, *supra* note 93, at 50 ("The submersible became an attractive platform not just because of legal gaps, but also because of the challenges in identifying and tracking such a vessel.").

high seas and in littoral operations."[128] As Professor Guilfoyle has written, such robust intelligence acquisition is the tie that binds effective defense and law enforcement operations in the maritime domain.[129] Moreover, while larger and more prominent warships provide a valuable deterrent effect, the possibility of deploying a number[130] of "smaller, and hence stealthier"[131]autonomous warships would make it more difficult for drug traffickers to avoid law enforcement vessels or to realize that they were being tracked by enforcement assets. In this regard, autonomous vessels promise to leverage one of the hallmark advantages of drug traffickers—i.e., stealth—as a powerful interdiction tool.

3. Reduced Cost

The daunting combination of a vast operating area, finite enforcement assets, and enterprising drug trafficking organizations demands a law enforcement response that is not only effective but efficient.[132] Over the past decade, the Coast Guard has worked to recapitalize an aging fleet of patrol ships and aircraft[133] due to a "flatlining" of budget appropriations and a consequent reduction in purchasing power.[134]At the same time, there have been persistent calls for the U.S. Department of Defense to reallocate spending away

128. Yoo, *supra* note 81, at 454.

129. *See* GUILFOYLE, *supra* note 90, at 301 ("In intercepting threats in the maritime domain, intelligence will always be crucial whether the mission is one of national defense or of law enforcement.").

130. *See* Yoo *supra* note 81, at 454 ("Unmanned naval vessels would . . . allow [ ] naval forces to deploy them in higher numbers . . .").

131. *Id.*

132. *See* Douglas Guilfoyle, *Maritime Law Enforcement Operations and Intelligence in an Age of Maritime Security*, 93 INTERNATIONAL LAW STUDIES 298, 300 (2017) ("Effective maritime law enforcement requires choices to be made about the deployment of finite assets. . . . Even the most well-resourced navies and coast guards cannot maintain a 'cordon of steel' around a national coastline.").

133. *See* RONALD O'ROURKE, CONG. RSCH. SERV., R42567, COAST GUARD CUTTER PROCUREMENT: BACKGROUND AND ISSUES FOR CONGRESS, summary (updated Dec. 22, 2020) ("The Coast Guard's program of record (POR) calls for procuring 8 National Security Cutters (NSCs), 25 Offshore Patrol Cutters (OPCs), and 58 Fast Response Cutters (FRCs) as replacements for 90 aging Coast Guard high endurance cutters, medium-endurance cutters, and patrol craft.").

134. Richard Sisk, *Coast Guard Budget Proposal 'Dead on Arrival' in Congress, Lawmaker Says*, MILITARY.COM (Apr. 9, 2019), https://www.military.com/daily-news/2019/04/09/coast-guard-budget-proposal-dead-arrival-congress-lawmaker-says.html.

from large, expensive naval vessels[135] and toward more cost-effective, asymmetric capabilities.[136] Further, the increasingly devastating repercussions of the COVID-19 outbreak, and consequent emergency economic stimulus measures, are expected to exert additional downward pressure on U.S. defense and homeland security budgets in the coming years.[137] Collectively, these factors signal a future in which maritime enforcement assets will need to be more cost-effective while maintaining operational efficacy.

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135. *See* Jessica T. Mathews, *America's Indefensible Defense Budget*, NEW YORK REVIEW OF BOOKS (July, 18, 2019), https://www.nybooks.com/articles/2019/07/18/americas-indefensible-defense-budget ("[T]he navy remains wedded to new aircraft carriers, but at $13 billion each they are arguably more an outdated symbol of twentieth-century power than an effective weapon system for a future in which they will be increasingly vulnerable to attack by high-speed, maneuverable missile that can be bought for a miniscule fraction of what a carrier costs.")

136. *See* Kurt M. Campbell & Jake Sullivan, *Competition Without Catastrophe*, FOREIGN AFFAIRS (Sept.-Oct. 2019), https://www.foreignaffairs.com/articles/china/competition-with-china-without-catastrophe ("Washington should reorient its investments away from expensive and vulnerable platforms, such as aircraft carriers, and toward cheaper asymmetric capabilities designed to discourage Chinese adventurism without spending vast sums.").

137. *See* Jim Thomas, *A Blueprint for Rebuilding America's Military After the Coronavirus*, NATIONAL INTEREST (Mar. 28, 2020), https://nationalinterest.org/feature/blueprint-rebuilding-americas-military-after-coronavirus-138282 ("Regardless of who is president, the forecast for U.S. defense spending just shifted from 'flat at best' to an almost certain decline.").

In light of these budgetary constraints, autonomous naval vessels[138] offer potentially vast cost savings.[139] These cost savings would principally be realized in the sharply reduced daily operating costs of autonomous patrol vessels. Unlike traditional warships, autonomous vessels require no expenditures for food, housing, or other amenities required by a human crew.[140] Similarly, autonomous vessels' "efficiencies realized in ship design and use of fuel" stand to bolster the fiscal sustainability of enforcement operations.[141] This is particularly true in the counterdrug context, where the considerable daily operating costs of traditional warships[142] are further heightened by substantial fuel expenditures needed to effectively patrol a vast operating area. As maritime law enforcement entities make tough choices about the use of finite resources to meet the demands of their varying mission sets, it will be

138. Some commentators have been careful to distinguish between naval operations and commercial shipping when evaluating cost savings associated with autonomous vessel technology. In the commercial context—particularly on large cargo ships or tankers—personnel costs represent only a fraction of operating costs. Moreover, the high cost of autonomous vessel technology may slow its adoption in commercial contexts, as compared with naval applications. *See, e.g.*, David Dubay, *Why We Will Never See Fully Autonomous Ships*, THE MARITIME EXECUTIVE (June 25, 2019), https://www.maritime-executive.com/editorials/why-we-will-never-see-fully-autonomous-commercial-ships ("For shipping companies, a switch to autonomous vessels promises cost savings from not having to pay for a master and crew, and perhaps from increased safety. But scores of new operators and technicians would be required to make a system of autonomous vessels work. The equipment to automate a ship will be extremely expensive and would introduce many new potential points of failure into commercial shipping."). My thanks to Ms. Dorota Lost-Sieminska for highlighting the important distinction between naval and commercial contexts when evaluating the cost-saving potential of autonomous vessels.

139. *See* Grome, *supra* note 19, at 45 ("The greatest advantage the Ghost Fleet presents over contemporary fleets and their vessels is the dramatic reduction in construction and operation costs."); *see also* Yoo, *supra* note 81, at 454 ("Unmanned naval vessels would also cost less, allowing naval forces to deploy them in greater numbers . . ..").

140. *See* Grome, *supra* note 19, at 45–46 ("The reduced cost is due to the smaller size of the [autonomous] vessel, principally due to the lack of sailors and their accompanying costs, such as food, housing, and other amenities."); *see also* Sinclair, *supra* note 13, at 19 (noting that drones are "inexpensive as compared to . . . their manned counterparts").

141. *See* Bernard Marr, *The Autonomous Ships of the Future: Run by Artificial Intelligence Rather Than a Crew*, FORBES (June 5, 2019), https://www.forbes.com/sites/bernardmarr/2019/06/05/the-incredible-autonomous-ships-of-the-future-run-by-artificial-intelligence-rather-than-a-crew/#79c0f1786fbf ("One study projected savings of more than $7 million over 25 years per autonomous vessel from fuel savings and crew supplies and salaries.").

142. *See* Grome, *supra* note 19, at 45 ("[T]he average cost to operate a U.S. destroyer in patrolling missions is an astounding $700,000 per day . . ..").

increasingly necessary to integrate autonomous vessel technology and capitalize on the promise of these cost savings.

B. Counterdrug Challenges of Autonomous Vessels: A New Tool of Trafficking

As discussed, the evolution of maritime drug trafficking has been marked by sophisticated methods of transporting and concealing illicit payloads.[143] From the repurposed trawler to the semi-submersible, the scope and speed of the traffickers' innovations—fueled by a stream of drug proceeds—has been striking. This history suggests that the advent of autonomous vessel technology will, regrettably, inure to the benefit not only of law enforcement entities but to the criminal enterprises they seek to interdict. In the counterdrug context, autonomous vessels are a classic double-edged sword.

1. Autonomous and Remote-Controlled Drug Trafficking

Transnational criminal organizations have successfully leveraged technology to generate income and facilitate their operations. For example, the notoriously ruthless[144] Zetas drug cartel installed an array of antennas and repeaters throughout Mexico, allowing the cartel to communicate via an encrypted, secure network.[145] The vast profits reaped by drug cartels[146] provide them the ability to invest heavily in such technology. Cartels have also demonstrated the ability to pursue a technological edge via other means, including the kidnapping of engineers.[147] Simply stated, drug cartels now view ad-

143. *See supra* notes 108–114 and accompanying text.

144. *See*, *e.g.*, *19 Bodies Hung From Bridge or Dismembered in Mexico Gang Fued*, NEW YORK TIMES (Aug. 8, 2019), https://www.nytimes.com/2019/08/08/world/americas/mexico-drug-feud-bodies-michoacan.html ("In 2012, the Zetas drug cartel dumped 49 decapitated bodies on a highway in northern Mexico, and that same year they strung nine bodies from an overpass and left 14 severed heads near the city hall.").

145. *See* Danielle Muoio, *Here's All the High-Tech Gear Cartels Use to Sneak Drugs into the US*, BUSINESS INSIDER (July 20, 2016), https://www.businessinsider.com/cartels-use-tech-to-sneak-drugs-into-the-us-2016-7.

146. *See* Patrick Radden Keefe, *Cocaine Incorporated*, NEW YORK TIMES (June 15, 2012), https://www.nytimes.com/2012/06/17/magazine/how-a-mexican-drug-cartel-makes-its-billions.html ("Mexican cartels reap $18 billion to $39 billion from drug sales in the United States each year.").

147. *See* Muoio, *supra* note 145 ("Zetas actually kidnapped engineers to get the job done.").

vanced technology as an operational imperative. As noted by Marc Goodman, a leading commentator on global security and prominent author in the area of high-tech crime, "Criminals perpetually update their techniques to incorporate the very latest emerging technologies into their modi operandi . . . . Organized crime groups have established themselves as early adopters of technology. Criminals embraced the online world long before the police ever contemplated it, and they have outpaced authorities ever since."[148]

Indeed, Goodman cites the design and construction of the SPSS "narco sub" as a prime example of drug cartels' early adoption of robotics technology.[149] Given the drug cartels' penchant for leading-edge innovation, he argues that developments in SPSS technology will lead ineluctably to the cartel's acquiring or inventing "autonomous underwater vehicles to transport narcotics."[150] While an autonomously operated SPSS has yet to be discovered, Goodman is quick to note that this does not mean that such a vessel doesn't exist. And, according to him, "if it doesn't exist, it will soon."[151]

While fully autonomous drug trafficking vessels appear imminent, nascent efforts to construct and operationalize remote-controlled drug trafficking vessels have been underway for some time.[152] In 2010, Assistant U.S. Attorney Joseph Ruddy prosecuted Gustavo Garcia-Velasquez, Lope Lopez-Ortega, and Carlos Vera for a criminal conspiracy involving the construction of such vessels.[153] The defendants' respective specializations—electrician, fiberglass fabricator, and liaison with remote-controlled submarine makers and buyers—facilitated the construction of remote-controlled

148. MARC GOODMAN, *Prologue* to FUTURE CRIMES: INSIDE THE DIGITAL UNDERGROUND AND THE BATTLE FOR OUR CONNECTED WORLD (2015).

149. Muoio, *supra* note 145 ("Narcos are early adopters of robotics . . . . Narco subs were, for many years, carrying . . . tons of kilos of cocaine and landing on the shores of Mexico.") (quoting Goodman).

150. *See id.*

151. *Id.*

152. *See* Christopher A. Nolin, *Telecommunications as a Weapon in the War of Modern Organized Crime*, 15 CATHOLIC UNIVERSITY JOURNAL OF COMMUNICATIONS LAW AND POLICY 231, 237 n.27 ("[Drug cartel leader Pablo] Escobar even built small, remote-controlled submarines to send up to two thousand kilos of cocaine to the waters off the coast of Puerto Rico. Divers then recovered the delivery and transferred it to Miami in cartel-owned speedboats.") (citing MARK BOWDEN, KILLING PABLO 34 (2001)).

153. Terrance G. Lichtenwald, Mara H. Steinhour & Frank S. Perri, *A Maritime Threat Assessment of Sea Based Criminal Organizations and Terrorist Operations*, 8 HOMELAND SECURITY AFFAIRS 1, 12–13 (2012).

vessels capable of "carry[ing] up to 1,800 kilograms of cocaine" and traversing one thousand nautical miles between refueling operations.[154] Though developing and implementing SPSS technology does not come cheap—one drug "super-sub" seized in 2011 was estimated to have cost at least $5 million[155]—the business case for cartels to develop autonomous drug delivery is compelling. The street value of a fully-laden SPSS can easily fetch drug profits into the hundreds of millions of dollars,[156] rendering nugatory any financial losses should a remote-controlled submersible veer off course or be seized.[157] In light of that business case and the premium that drug cartels place on technological innovation, it is hard to imagine a future of maritime drug trafficking that does not increasingly incorporate remote-controlled and fully autonomous drug delivery.

2. Chasing Ghosts: The Challenge of Prosecuting Remote Traffickers

Beyond the lure of profits, drug cartels have an independent, powerful incentive to incorporate remote-controlled and fully autonomous drug trafficking technology: evading prosecution. Lawmakers in the United States have erected a formidable lattice of overlapping criminal statutes that have proven effective at reaching and criminalizing drug trafficking that occurs far from U.S. shores. The flagship U.S. maritime counterdrug statute, the Maritime Drug Law Enforcement Act (MDLEA),[158] extended the reach of its predecessor, the Marijuana on the High Seas Act (MHSA),[159] to confer U.S. criminal jurisdiction over a wide range of vessels including, *inter alia*,

154. *Id.* at 13.

155. *See* Jim Popkin, *Authorities in Awe of Drug Runners' Jungle-Built, Kevlar-Coated Supersubs*, WIRED (Mar. 29, 2011), https://www.wired.com/2011/03/ff_drugsubs/.

156. *See id.* ("The most valuable feature [of the SPSS], though, is the cargo bay, capable of holding up to 9 tons of cocaine—a street value of about $250 million.").

157. *See* Wilson, *supra* note 93, at 40 ("Although the cost of constructing a submersible is high . . . those costs are mitigated by the fact that such vessels can transport several tons of cocaine in one voyage. Thus . . . a TCO could '[d]eploy five vessels at a combined total layout of $100 million, successfully deliver one, and you double your investment.'") (quoting Wade F. Wilkenson, *A New Underwater Threat*, PROCEEDINGS (Oct. 14. 2009), https://www.usni.org/magazines/proceedings/2008/october/new-underwater-threat).

158. *See* 21 U.S.C. § 955a(a) (1982), repealed by Maritime Drug Law Enforcement Act of 1986, 46 U.S.C. app. § 1903 (current version at 46 U.S.C. §§ 70501–70508 (2016)) [hereinafter MDLEA]

159. *See* Casavant, *supra* note 92, at 200–201.

U.S. flagged vessels, vessels owned by a U.S. person or business entity, foreign vessels on the high seas, and stateless vessels.[160] The MDLEA prohibits an individual onboard a "covered vessel" from knowingly or intentionally manufacturing, distributing, or possessing with intent to manufacture or distribute, a controlled substance, and "applies even though the act is committed outside the territorial jurisdiction of the United States."[161] The MDLEA further expands the jurisdictional reach of the MHSA by, among other things, broadening the definition of stateless vessels and providing for application to "foreign ships with foreign crews as long as the flag State consents."[162] The advent of SPSS drug trafficking vessels—frequently sunk "at the first sign of law enforcement"[163]—laid bare unforeseen gaps in the otherwise robust MDLEA framework.[164] Specifically, SPSS "drug smugglers could skirt prosecution if law enforcement officials failed to recover evidence of illegal activity."[165] Given the ease with which SPSS could be scuttled and sunk, as was often the case,[166] Congress responded by enacting the Drug Trafficking Vessel Interdiction Act (DTVIA),[167]which makes it a felony to operate, or merely embark upon, a stateless submersible or semi-submersible vessel seaward of any State's territorial sea with the intent to evade detection.[168] The DTVIA thus criminalizes conduct that *facilitates* drug trafficking,[169] irrespective of whether individuals were actually trafficking drugs

160. *Id.*

161. 46 U.S.C. § 70503(a)-(b).

162. *See* Allyson Bennett, *That Sinking Feeling: Stateless Ships, Universal Jurisdiction, and the Drug Trafficking Vessel Interdiction Act*, 37 YALE JOURNAL OF INTERNATIONAL LAW 433, 442 (2012).

163. *Id.* at 445.

164. *Id.* at 434.

165. Wilson, *supra* note 93, at 36.

166. *See id.* at 52 ("The legislative history of the DTVIA emphasizes that SPSS platforms 'pose a formidable security threat because they are difficult to detect and easy to scuttle or sink. These vessels therefore facilitate the destruction of evidence and hinder prosecution of smuggling offenses.'").

167. Bennett, *supra* note 162, at 434 ("The DTVIA responds to these practical difficulties by criminalizing the operation of a submersible or semi-submersible vessel without nationality and the intent to evade detection.").

168. 18 U.S.C. § 2285(a).

169. *See* Ferguson v. United States, No. 1:17-cr-20877-UU, 2020 U.S. Dist. LEXIS 21549, at *17 (S.D. Fl. Jan. 31, 2020) (noting that the DTVIA "was a valid exercise of [Congress'] authority to target criminal conduct that facilitates drug trafficking").

when found aboard an SPSS.[170] Moreover, federal appellate courts have upheld the DTVIA[171] under the universal[172] and protective[173] principle of international law.

The DTVIA highlights the underlying "'cat-and-mouse' dynamic between narco-traffickers and interdiction forces."[174] Indeed, the most recent iteration of that dynamic—elite aerial and surface law enforcement operations pitted against sophisticated drug trafficking vessels and submersibles—was the prime mover of this legislative innovation. But the specter of remote-controlled and fully autonomous drug trafficking vessels presents a new and formidable challenge for those on the enforcement side of the ledger—the cats if you will. The nub of this problem involves the related, but distinct, issues of identification and jurisdiction.

Identifying the operator of a remote-controlled drug trafficking vessel is exceedingly difficult. As an initial matter, attribution to a specific remote operator or cybercriminal is a notoriously fraught undertaking for even the most technologically advanced governments.[175] A remote operator enjoys a

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170. *Id.* ("The DTVIA does not require a showing that the outlawed vessel was actually being used in furtherance of a drug trafficking crime in order to be a valid exercise of Congressional authority.").

171. *See, e.g.*, United States v. Saac, 632 F.3d 1203 (11th Cir. 2011).

172. *Id.* at 1210 ("According to this principle, a nation may pass laws to define and punish certain crimes to be considered of 'universal concern' . . . . We now conclude that the DTVIA is also justified under the universal principle and thus a constitutional exercise of Congress's power under the High Seas Clause.").

173. *Id.* at 1211 ("Given Congress's findings, the 'protective principle' of international law provides an equally compelling reason to uphold the DTVIA. Under that principle, a nation may "assert jurisdiction over a person whose conduct outside the nation's territory threatens the nation's security or could potentially interfere with the operation of its governmental functions.").

174. *See* Nicholar R. Magliocca et al., *Modeling Cocaine Traffickers and Counterdrug Interdiction Forces as a Complex Adaptive System*, 116 PROCEEDINGS OF THE NATIONAL ACADEMIES OF SCIENCE OF THE UNITED STATES OF AMERICA 7784 (2019).

175. *See* David J. Lynch, *How Experts Track Global Cyber Criminals*, FINANCIAL TIMES (June 1, 2016), https://www.ft.com/content/e61146e0-2808-11e6-8ba3-cdd781d02d89 ("Answering the 'whodunnit' question is not as straightforward in cyber space as in the physical world."); *see also* Lily Hay Newman, *Hacker Lexicon: What is the Attribution Problem?* WIRED (Dec. 24, 2016), https://www.wired.com/2016/12/hacker-lexicon-attribution-problem/ ("Attribution is extremely difficult and requires intelligence sources that are reliable and accurate. The intelligence community typically monitors specific groups and activity in order to have high confidence. It's not a perfect system, but the US is one of the

cloak of anonymity, may be located thousands of miles from the site of the vessel interdiction, and can leverage encryption technology to thwart digital intrusion by law enforcement.[176] In a very real sense, the remote operator can "scuttle" the vessel—or more precisely, his digital connection to it—in a matter of seconds.[177] Indeed, as former assistant attorney general for national security John P. Carlin observed, attributing activity on the internet and electronic media is uniquely challenging because malicious electronic activity can be routed through "third-party proxies."[178] Moreover, even successful attribution to an originating computer is insufficient where, as if often the case, "the person or group that controlled it" cannot be identified.[179]

The challenges of identifying a remote electronic or cyber operator are being examined in a growing body of academic literature[180] and government analysis[181] on the law of cyber attribution. While these materials focus their analysis on various forms of computer network exploitation, the thrust of the legal inquiry for electronically facilitated drug trafficking is much the

best.") (quoting David Kennedy, CEO of security firm TrustedSec and former National Security Agency employee).

176. *See supra* notes 145–146 and accompanying text.

177. *See* Lynch, *supra* note 175 (Further complicating identification efforts, cyber criminals can mask their actual location by giving the appearance they are located somewhere else, Lynch noting that cyber criminals "often mask their location by giving bouncing electronic commands off servers in several countries.").

178. See John P. Carlin, *Detect, Disrupt, Deter: A Whole-of-Government Approach to National Security Cyber Threats*, 7 HARVARD NATIONAL SECURITY LAW JOURNAL 392, 409 (2016).

179. *See id.*

180. *See, e.g.*, Oona Hathaway, Rebecca Crootof, Philip Levitz, Haley Nix, Aileen Nowlin, William Perdue & Julia Spiegel, *The Law of Cyber-Attack*, 100 CALIFORNIA LAW REVIEW 817 (2012); Kristen E. Eichensehr, *The Law & Politics of Cyberattack Attribution*, 67 UCLA LAW REVIEW 520, 522 (2020)("Figuring out who's doing what to whom and publicly identifying those responsible for bad acts in cyberspace are key elements of increasing efforts to hold those actors more accountable."); Herbert Lin, *Attribution of Malicious Cyber Incidents*, Hoover Institution Aegis Paper Series No. 1607 (2016); Jack Goldsmith, *How Cyber Changes the Laws of War*, 24 EUROPEAN JOURNAL OF INTERNATIONAL LAW 129 (2013); TALLIN MANUAL 2.0 ON THE INTERNATIONAL LAW APPLICABLE TO CYBER OPERATIONS (Michael N. Schmitt gen. ed., 2017).

181. *See, e.g.*, OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE, A GUIDE TO CYBER ATTRIBUTION (2018), https://www.dni.gov/files/CTIIC/documents/ODNI_A_Guide_to_Cyber_Attribution.pdf; *see also* U.S. DEPARTMENT OF JUSTICE, REPORT OF THE ATTORNEY GENERAL'S CYBER DIGITAL TASK FORCE (2018), https://fas.org/irp/eprint/ag-cyber.pdf; COUNCIL OF ECONOMIC ADVISORS, THE COST OF MALICIOUS CYBER ACTIVITY TO THE U.S. ECONOMY (2018), https://www.whitehouse.gov/wp-content/uploads/2018/03/The-Cost-of-Malicious-Cyber-Activity-to-the-U.S.-Economy.pdf.

same. Namely, the assignment of responsibility for malicious activity effectuated through an electronic medium.

Professor Eichensehr, a leading national security and cybercrime scholar, has noted that accurate attribution in cyberspace is a "crucial predicate" to criminal indictment.[182] Thus, the application of both the MDLEA and DTVIA, which criminalize the conduct of "an individual," are frustrated by the difficult task of identifying a specific remote operator. Similar challenges are faced in the case of fully autonomous drug trafficking vessels. As noted by Professor Allen, thorny questions regarding whether an autonomous vessel's programmer or program team are properly viewed as the vessel's master have yet to be resolved.[183] Moreover, even assuming *arguendo* an affirmative answer to this question, the chances of identifying such programmers may prove vanishingly small. In this regard, counterdrug law enforcement officers may feel as if they are chasing ghosts.

Finally, in the event a remote operator or autonomous vessel programmer (or program team) can be located, the question remains whether a U.S. federal court can properly exert jurisdiction over that person, wherever found, under the MDLEA or DTVIA. For purposes of this analysis, it can reasonably be assumed that a remote-controlled or autonomous vessel used to transport drugs would lack an obvious connection to its place of origin or operator.[184] Thus, a remote-controlled or autonomous drug trafficking vessel is unlikely to be registered or flying a flag and (by definition) has no master aboard to make a claim of nationality for the vessel. Under both the MDLEA[185] and DTVIA[186] such a vessel would be without nationality—a stateless vessel. This determination does not, however, end the jurisdictional

182. Eichensehr, *supra* note 180, at 522.

183. *See supra* note 37 and accompanying text.

184. *See* Bennett, *supra* note 162, at 440 ("The law of the flag has proven ill-suited to combating the international drug trade. The ships used to transport drugs are often unregistered, allowing them to effectively operate outside of any state's control.").

185. *See* 46 U.S.C. § 70502(e)(1) (2018) ("A claim of nationality or registry under this section includes only (1) possession on board the vessel the production evidencing the vessel's nationality as provided in Article 5 of the 1958 Convention on the High Sea; (2) flying the nation's ensign or flag; or (3) a verbal claim of nationality or registry by the master or individual in charge of the vessel.").

186. 18 U.S.C.A. § 2285(d) (limiting claims of nationality or registry to those included in the MDLEA).

inquiry under each statute. Rather, autonomous vessels present novel questions regarding the extraterritorial application of U.S. criminal law.[187]

i. MDLEA

The MDLEA explicitly provides for extraterritorial application,[188] and appellate courts have generally found this "straightforward expression of extraterritorial application" determinative.[189] While the extraterritorial application of the MDLEA is well-established,[190] it is less clear that Congress contemplated reaching the conduct of an extraterritorial remote operator or programmer of a drug-trafficking vessel. Specifically, the MDLEA's proscribed conduct refers to an "individual" being "on board" a vessel, suggesting that remote or autonomous operation may fall outside the proscriptive sweep of the statute.

Appellate court interpretations of the MDLEA's statutory term "on board" suggest that while a remote operator or autonomous vessel programmer may be beyond the reach of the MDLEA's substantive offense under §

187. *See generally* CHARLES DOYLE, CONG. RSCH. SERV., RS22497, EXTRATERRITORIAL APPLICATION OF AMERICAN CRIMINAL LAW, summary (updated Oct. 31, 2016) ("Criminal law is usually territorial. It is a matter of the law of the place where it occurs. Nevertheless, a number of American criminal laws apply extraterritorially outside the United States. Application is generally a question of legislative intent, express or implied. There are two exceptions. First the statute must come within Congress's constitutional authority to enact. Second, neither the statute nor its application may violate due process or any other constitutional prohibition.").

188. *See* 46 U.S.C. § 70503(b) (noting that the MDLEA's prohibitions apply "even though the act is committed outside the territorial jurisdiction of the United States"); *see also* DOYLE, *supra* note 187, at 17 ("The [MDLEA] is somewhat unusual in that it expressly authorizes extraterritorial coverage of federal criminal law predicated on nothing more than the consent of the state with primary criminal jurisdiction.").

189. *See, e.g.*, United States v. Ballestas, 795 F.3d 138, 144 (D.C. Cir. 2015); *but see* United States v. Bellaizac-Hurtado, 700 F.3d 1245 (11th Cir. 2012) (reasoning that, because drug trafficking is not a violation of customary international law, Congress exceeded its power under the offenses clause when it proscribed defendants' conduct in Panamanian territorial waters).

190. *See* United States v. Carvajal, 924 F. Supp. 2d 219, 240 (D. D.C. 2013) ("Courts have uniformly ruled that MDLEA applies to conduct outside the United States."); *see also* DOYLE, *supra* note 187, at 15 ("Congress's declaration that a particular statute is to apply outside the United States is the most obvious evidence of intent to create extraterritorial jurisdiction.").

7503(a), they would still be subject to the MDLEA's conspiracy offense under § 7506(b), which provides that "a person attempting or conspiring" to violate the MDLEA's substantive offense is "subject to the same penalties." In *United States v. Ballestas*,[191] the U.S. Court of Appeals for the D.C. Circuit upheld the conviction of Ernesto Ballestas, a Colombian national, under the MDLEA's conspiracy provision. Though Ballestas had never been on board the interdicted drug trafficking vessels, while in Colombia he was involved in a "drug trafficking organization that regularly transported drugs on board vessels traveling over the high seas."[192] The D.C. Circuit roundly rejected Ballestas's contention that the qualifying phrase "on board" suggests that "the MDLEA should apply extraterritorially only when a person's charged conduct took place on board."[193] In so doing, the D.C. Circuit found that conspiracy is established under the MDLEA where "criminal conduct took place 'on board' vessels covered by the MDLEA" and where "that criminal conduct is attributable to Ballestas as a co-conspirator."[194] Applying the reasoning of *Ballestas* suggests that a remote operator or programmer of a drug trafficking vessel would be a co-conspirator under the MDLEA, whose "overt act" in programming or remotely operating a drug trafficking vessel was "done in furtherance of the conspiracy." However, the *Ballestas* court's dicta suggesting that the presence of other co-conspirators *on board* the interdicted vessel, attributable to Ballestas, would satisfy "any 'on board a vessel' requirement that might arguably circumscribe the MDLEA's extraterritorial application," merits consideration.[195] While the question was not squarely before the court, this dicta could be read as indicating that *someone* must be aboard the interdicted vessel to sustain the MDLEA conspiracy conviction of an extraterritorial programmer or remote operator.

ii. DTVIA

Should the question of prosecuting a remote operator or autonomous vessel programmer for maritime drug trafficking arise, the extraterritorial application and jurisdictional reach of the DTVIA is likely to be upheld. As with

191. *Ballestas*, 795 F.3d at 409.
192. *Id.*
193. *Id.*
194. *Id.*
195. *Id.*

the MDLEA, Congress specifically provided for the extraterritorial application of the DTVIA.[196] Federal courts, observing that the DTVIA expressly applies to submersible and semi-submersible vessels without nationality, have had no trouble in upholding its extraterritorial application, finding that it does not offend constitutional due process requirements.[197] Nor is the DTVIA textually limited, like the MDLEA, to the conduct of individuals "on board" a vessel covered by the statute. Rather, the DTVIA criminalizes the conduct of one who "who *knowingly operates*, or attempts or conspires to operate, by any means, *or embarks* in any submersible vessel or semi-submersible that is without nationality."[198]

The "plain meaning rule" provides that courts should follow the plain meaning of the statutory text unless the plain meaning produces an absurd result.[199] As the U.S. Supreme Court has become increasingly focused on text as the lodestar of statutory interpretation, so too has the prominence of the plain meaning rule.[200] As then-Judge Kavanaugh noted in 2016, "[i]f the text is sufficiently clear, the text usually controls."[201]

The text of the DTVIA is sufficiently clear. First, it clearly criminalizes the mere "operat[ion]" of a submersible or semi-submersible vessel without nationality. Moreover, "operat[ion]" may be accomplished "by *any* means," suggesting that Congress intended to criminalize a wide array of possible

196. 18 U.S.C. § 2285(c).

197. *See, e.g.*, United States v. Ibarguen-Mosquera, 634 F. 3d 1370, 1379 (D.C. Cir. 2011) (citations omitted) ("We conclude . . . that international law permits any nation to subject stateless vessels on the high seas to its jurisdiction . . . Jurisdiction exists solely as a consequence of the vessel's status as stateless.' Because extraterritorial jurisdiction is proper, we conclude that the enactment of the DTVIA does not offend the Due Process Clause of the Constitution.").

198. 18 U.S.C. § 2285(a) (emphasis added).

199. *See* WILLIAM N. ESKRIDGE JR., ABBE R. GLUCK & VICTORIA F. NOURSE, STATUTES, REGULATIONS, AND INTERPRETATION 1091 (2014); *see also* Arlington Central School Dist. Bd. of Ed. v. Murphy, 548 U.S. 291, 295 (2006) (citations omitted) ("When the statutory 'language is plain, the sole function of the court—at least where the disposition required by the text is not absurd—is to enforce it according to its terms.'")

200. *See* Brett M. Kavanaugh, *Fixing Statutory Interpretation*, 129 HARVARD LAW REVIEW 2118 (2016) ("Statutory text matters much more than it once did . . . . The text of the law is the law.").

201. *Id.*

modes of operation.[202] Given the broad scope of the statutory terms "by any means," both extraterritorial operation of a remote-controlled SPSS or submersible vessel and extraterritorial programming of an autonomous SPSS or submersible vessel would likely constitute "operat[ion]" within the meaning of the DTVIA. Moreover, the statute uses the conjunction "or" to distinguish an alternate, independent mode of offense—embarkation. Thus, the DTVIA makes clear that operation alone,[203] irrespective of embarkation, is sufficient to complete the offense.

In conclusion, the advent of autonomous vessel technology bears both promise and peril in the context of maritime drug trafficking. For law enforcement officials, cost-effective autonomous vessels can be leveraged to mitigate the "tyranny of distance" that has proven the Achilles heel of traditional warships seeking to stem maritime drug flows. Moreover, cutting-edge sensor and infrared technology packages aboard autonomous and remote-controlled enforcement assets can aid law enforcement in detecting low-profile and submersible drug trafficking vessels.

Regrettably, drug cartels have proven willing to invest heavily in technology to advance illicit aims, and cartels will likely employ autonomous vessel capabilities with devastating efficiency. Even where autonomous or remote-controlled drug trafficking vessels are found and interdicted, law enforcement officers will face the enduring challenge of attributing illicit network action or electronic commands to a specific person.

Finally, this section analyzed the jurisdictional reach of the MDLEA and DTVIA, concluding that while both are likely sufficient to reach the extraterritorial conduct of a remote operator or programmer, federal courts will need to further consider if and to what extent to the MDLEA's "on board a vessel" requirement truncates the MDLEA's extraterritorial application in the context of autonomous or remote-controlled vessels.

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202. *See* Yates v. United States, 574 U.S. 528, 555 (2015) (Kagan, J., dissenting) ("This Court has time and again recognized that 'any' has 'an expansive meaning,' bringing within a statute's reach all types of the item . . . to which the law refers.").

203. The DTVIA also includes as an element of the offense an "intent to evade detection." Remote operation of an SPSS, or programming of an autonomous SPSS, are not inconsistent with, and would likely support, the establishment of an intent to evade detection.

IV. NAVIGATIONAL SAFETY

As with search and rescue and maritime counterdrug operations, autonomous vessel technology has profound implications for the future of navigational safety. A number of commentators have posited that autonomous vessel technology will improve navigational safety writ large by eliminating human errors and incorporating a robust suite of sensor technology.[204] But before these benefits can be realized, a number of threshold questions must be addressed to ensure that autonomous vessels can comply with the letter and spirit of the existing navigational safety regime. As the U.S. federal government's "navigation safety expert" and designated center of excellence for navigational safety, the Coast Guard will play a pivotal role in addressing urgent questions posed by the implementation of remote-controlled and autonomous vessel technologies in the commercial and military context.[205]

The corpus of international law, treaties, and regulations governing navigational safety was drafted in contemplation of crewed vessels. Thus, important questions arise regarding if and to what extent existing instruments can adequately provide for the navigational safety of remote-controlled and autonomous vessels.[206] The crux of the challenge for the "international maritime legal system" was well-articulated by Professor Chircop:

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204. *See, e.g.*, Chircop, *supra* note 21, at 5 (noting that unmanned and autonomous ships "will likely be navigated more accurately and consequently with fewer errors, if any, than crewed vessels"); *see also* Robert Veal, Michael Tsimplis & Andrew Serdy, *The Legal Status and Operation of Unmanned Maritime Vehicles*, 50 OCEAN DEVELOPMENT AND COASTAL Law 23, 40 (2018) ("Greater automation and autonomy in the marine sector seem inevitable and they have the potential, if managed properly, to make maritime activity safer and more efficient.").

205. *See* Director, Marine Transportation Systems, U.S. Coast Guard, COMDTINST 16003.2B, Marine Planning to Operate and Maintain the Marine Transportation System (MTS) and Implement National Policy app. B-1 (2019) ("The U.S. Coast Guard is the navigation safety expert for the Federal Government, and serves as it navigation safety center of excellence.").

206. *See* Frederick J. Kenney, *Global Regulation of Ships: The Future of Development and Implementation at the International Maritime Organization*, 42 TULANE MARITIME LAW JOURNAL 259, 264 (2018) ("The pace of technological change is constantly increasing, and professionals wonder if regulatory processes can keep pace with technology, such as potential new developments in autonomous vessels. If they cannot keep pace, current regulatory processes must adapt.").

> Consisting of conventions and other legal instruments of the IMO, international maritime regulation addresses all ships and is largely premised on human presence on board in the control of the navigation of the ship, as well as performing contingent functions such as provision of notices, log book entries, reporting, and responding to distress calls for assistance. The provision of certain services to ships is also premised on human interaction, such as in the case of pilotage where the master and [officer of the watch] cooperate with the pilot in formulating the passage plan and taking and executing navigation instructions. The human element is underscored by trained crews.[207]

Because the extant legal and regulatory landscape is "premised on human presence on board," it is anticipated that at least some changes will need to be made to bedrock navigational safety instruments, including the COLREGS and SOLAS Convention, in order to safely accommodate remote-controlled and autonomous vessels operations.[208] A comprehensive analysis of the full extent to which existing international instruments and related regulations may need to be adapted —a task currently underway via the IMO's MASS regulatory scoping exercise[209]—is beyond the scope of this article.[210] However, this section seeks to identify and analyze those areas of the regulatory and legal landscape that most urgently implicate navigational safety issues raised by MASS operations.

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207. *See* Chircop, *supra* note 21, at 20.

208. *See* Letter from Mr. J.G. Lantz, Director, Commercial Regulations and Standards, U.S. Coast Guard, COMDT (CG-5PS), to Mr. Kitack Lim, IMO Secretary-General (Jan. 15, 2016) ("The major challenges include the need to ensure that safety of navigation and the protection of life and property at sea, and the safe and proper operation of all manned vessels and unmanned vehicles. Properly developed Best Practices, coupled with appropriate COLREGs/Inland Navigation Rules changes, will ensure these challenges can be met. IMO Conventions, such as the COLREGS and SOLAS, will likely need amendments to address ship-to-ship movements and communications requirements for their safe operation."); s*ee also* Swain, *supra* note 12, at 137 n.81.

209. *See supra* note 20–21 and accompanying text.

210. The potentially vast autonomous vessel implications for extant legal and regulatory regimes poses this problem across the academic literature. *See, e.g.*, Chircop, *supra* note 21, at 20 ("[A] selection of salient instruments and provisions are discussed to exemplify the potential impacts of MASS on contemporary maritime regulation, while acknowledging that a comprehensive analysis of all IMO regulations will be needed to ascertain the full regulatory impact of MASS.").

A. Collision Avoidance

The COLREGS, which prescribe the maritime "Rules of the Road," are the touchstone for the safe navigation and interaction of ships at sea.[211] The substance and format of the COLREGS are largely mirrored by the U.S. Inland Navigation Rules,[212] which were finalized in the years following the adoption of the COLREGS. Given the substantial similarities between the U.S. Inland Navigation Rules and the COLREGS, this analysis will refer only to the rules and text of the latter.

A threshold question is whether the COLREGS apply to MASS operations. Under Rule 1(a), the COLREGS "apply to all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels."[213] The word "vessel" is further defined to include "every description of watercraft, including non-displacement craft, WIG craft, and seaplanes, used or capable of being used as a means of transportation on water."[214] While much ink has been spilled on the question of whether a MASS constitutes a "vessel,"[215] this article urges that this question need not detain us long. Indeed, the weight of scholarly opinion, supported by broad interpretations of the

211. *See Rules of the Road*, USCG, https://www.dco.uscg.mil/NavRules/ (last visited Jan. 21, 2021) ("Professional mariners must be proficient in the rules of the road but all mariners should know and understand the Rules. The Rules are legally binding and application of them makes the waterways safer for everyone.").

212. *Id.* ("It is important to note that with the exception of Annex V to the Inland Rules, the International and Inland Rules and Annexes are very similar in both content and format.").

213. COLREGS, *supra* note 50, r. 1(a).

214. *Id.* r. 3(a).

215. *See* Klein, *supra* note 17, at 250 ("Significant discussion has also emerged around the word 'vessel' or 'ship,' particularly given the varied definitions of ships that are found in different international instruments. This may explain why the word 'vehicles' has been preferred in the terminology."); *see also* Gotthard Mark Gauci, *Is it a Vessel, a Ship or a Boat, is it Just a Craft, or is it Merely a Contrivance*, 47 JOURNAL OF MARITIME LAW AND COMMERCE 479, 479 (2016) ("[L]egislators have struggled to define the terms 'ships' and 'vessel,' and such definitions have been further beset by interpretational problems. The emergence of new commercial craft, including autonomous vessels . . . has plagued maritime law."); *see also* Chircop, *supra* note 21, at 9 ("The early discourse on MASS raised the question whether the autonomous vessels is in fact a 'ship' as generally understood in international maritime law in order to ascertain its legal status and application to the various public and private maritime law conventions.").

word "vessel" or "ship" across the treaty landscape,[216] tilts heavily in favor of finding that MASS are indeed "vessels" subject to the COLREGS.[217] There is also a prevailing majority, "perhaps a consensus," among IMO member-States that at least some unmanned maritime vehicles are "ships."[218] As noted by Professor Allen, this is as it should be: a COLREGS interpretation that is sufficiently broad to encompass MASS operations will better advance the COLREGS' object and purpose of collision avoidance.[219]

Having determined that MASS constitute a "vessel" subject to the COLREGS, certain COLREGS provisions present immediately apparent problems for MASS compliance. Most prominent among these is COLREGS Rule 5, which requires that "[e]very vessel shall at all times maintain a proper look-out by sight and hearing . . . ."[220] The ability of a MASS to comply with this provision turns on what is meant by maintenance of a look-out "by sight and hearing."[221] Some authors have suggested that if a MASS had a sufficiently robust suite of auditory and visual sensors to constitute the "functional equivalent" of a lookout by "sight and hearing," it could be deemed in compliance with Rule 5.[222]

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216. *See* Kraska, *supra* note 9, at 52 ("There is ample support in multilateral conventions for the proposition that [maritime unmanned vehicles] are 'vessels' or 'ships.'").

217. *See* Chircop, *supra* note 21, at 26 ("Although unmanned, MASS are required to observe the COLREGS and the underlying standards of good seamanship. The rules are explicit in their reference to vessels and therefore do not provide any immediate problem of textual interpretation. The definition of vessel [in Rule 3(a)] easily covers MASS."); *see also* Kraska, *supra* note 9, at 64 ("In some instances, such as the definition of a 'vessel' in treaty construction and state practice, it is clear that unmanned systems enjoy the same legal status as ships."); Swain, *supra* note 12, at 128 ("[T]here is no overriding policy rationale for treating military and non-military UMSs vessel status differently under the COLREGS, and navigation safety would be furthered by maximum recognition of UMSs as vessels, to the extent supported by law.").

218. Allen, *supra* note 10, at 503.

219. *Id.*

220. COLREGS, *supra* note 50, r. 5.

221. *See* Pritchett, *supra* note 22, at 204–5 ("Another example, and one which is perhaps more problematic, is the requirement found in the [COLREGS] that every vessel must 'at all times maintain a look-out by sight and hearing.' As with radio watches, it is currently unclear whether a USV's autonomous or remote operation systems can fulfill this requirement.").

222. *See, e.g.*, Swain, *supra* note 12, at 141 ("[T]his paper asserts that a broad reading of Rule 5, considering sensors the functional equivalent of 'sight and hearing,' is reasonable.").

This author is less sanguine. As an initial matter, unlike the SOLAS or STCW conventions, the COLREGS "do not include provisions for the substitution of equivalents for its requirements."[223] Further, commentators have correctly observed that "sight and hearing" are inherently "human qualities" and thus textually committed to being carried out by a human watchstander.[224] Still, some have urged that various technological advances have already breathed some interpretive flexibility into the seemingly rigid requirements of Rule 5. For example, Professor Ringbom notes that SOLAS Regulation V/19, which addresses totally enclosed bridges, provides for the use of a "sound reception system" such that the navigating officer on the bridge can hear sound signals.[225] It can thus be argued that this SOLAS provision "effectively modifies the COLREGS Rule 5" and "accepts the prospect that human functions may be replaced by technology, at least as far as situational awareness is concerned."[226]

But a de facto "modification" to Rule 5 via a technological aid to the "hearing" of a mariner is on a different analytical plane than the technological *replacement* of the mariner.[227] Moreover, it is not at all clear that even the most mature sensor technology would provide a remote operator, or fully autonomous interface, a "full appraisal of the situation and the risk of collision," as mandated by Rule 5.[228] Given the critical safety functions provided by the lookout, unless such advanced technology is achieved, it is "unrealistic to expect that anything less than the equivalent of the sight of onboard seafarers will be accepted by regulators."[229] Thus, advocates of a "functional" approach to Rule 5 in the context of MASS operations must yield to the reality that sensors have yet to eclipse the human eye or ear in providing a "full appraisal" of the situation and risk of collision. A failure to acknowledge

223. Allen, *supra* note 10, at 503.

224. Ringbom, *supra* note 38, at 153.

225. *Id.*

226. *Id.*

227. *See id.* ("Whether the same logic could be extended to replace the entire lookout function as required in Rule 5 is more uncertain. The matter depends on whether the wording and spirit of Rule 5 is broad enough to authorize a replacement of the human looking by various types of cameras, radar, audio technology, and other technical solutions, assuming that the technologies used are at least as effective and safe as diligent humans performing the lookout functions.").

228. COLREGS, *supra* note 50, r. 5.

229. Veal, Tsimplis & Serdy, *supra* note 204, at 39.

these limitations will both imperil mariners and undermine the "text, content, and purpose" of the COLREGS.[230]

The ability of MASS to comply with Rule 2 of the COLREGS, "Responsibility," has also been questioned.[231] To facilitate the analysis of this provision, it is reproduced in its entirety:

> (a) Nothing in these Rules shall exonerate any vessel, or the owner, master, or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.
>
> (b) In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger.[232]

Paragraph (a) of Rule 2 establishes a standard of conduct "required by the ordinary practice of seamen." Properly discharging this duty requires, by necessary implication, human judgment.[233] That conclusion is reinforced by paragraph (b), which contemplates interpretation of the rules according to a "due regard" standard, an inherently imprecise amalgam of the "entire collection of duties and responsibilities [that] reflect internationally accepted norms" of conduct.[234] Further, it makes clear that properly construing the rules may, in some cases, require a *departure from them* to avoid danger. There is a strong argument that a remote-controlled vessel, piloted according to the "ordinary practice of seamen" as dictated by a continuing cycle of human

230. *See* Allen, *supra* note 10, at 503 ("[S]uggestions to construe the term look-out by 'sight and hearing' in a way that it will be satisfied by electro-optical devices as 'equivalents,' and 'master,' 'commander,' or 'crew' such that a shoreside operator or operations team satisfy the requirement might satisfy advocates of a functional approach to treaty interpretation, but the Vienna Convention on Treaties prescribes a more formalistic method for construing treaties based on the text, content, and purpose of the treaty.").

231. *See, e.g.*, Swain, *supra* note 12, at 139-40 ("At first look, Rule 2 on Responsibility . . . and Rule 5 on Look-outs . . . present the most difficulty for [unmanned maritime systems] because these rules appear to require the involvement of humans, at least implicitly. . .. [Rule 2] implies a degree of human or human-like decision-making").

232. COLREGS, *supra* note 50, r. 2.

233. *See* Ringbom, *supra* note 38, at 155 (noting that COLREGS Rule 2 "explicitly requires human judgment in the navigational decision-making loop").

234. *See* JAMES KRASKA, MARITIME POWER AND THE LAW OF THE SEA 265 (2011).

judgment, could indeed comply with Rule 2(a).[235] Similarly, a remote operator permanently in the navigational decision-making loop would likely be able to apply prevailing notions of "due regard" to avoid danger or collision.[236]

For a fully autonomous vessel, however, these conclusions are much less certain. As an initial matter, even the most intrepid programmer would struggle to translate the notion of "good seamanship"—a human-focused, judgment-laden standard—into an autonomous navigation system.[237] In essence, the question of whether a fully autonomous MASS can comply with COLREGS Rule 2 is bound up with the reality that this Rule, among others, is inextricably linked to the "influence of human decision-making and conduct."[238] While it is likely feasible to develop an algorithm that can capture and apply what is contained in the four corners of a given COLREGS rule,[239] Rule 2 contemplates more. Indeed, despite the necessary precision of the COLREGS, the proper application of a given rule "depends on a human's ability to use common sense to not only determine if a situation currently

235. *See* Ringbom, *supra* note 38, at 155 ("The quoted rules, as with COLREGS generally, are neutral with respect to who makes the decision or from what location."); *see also* Swain, *supra* note 12, at 140 ("Rule 2 requirements should not present a rules-based challenge for remote-controlled UMSs because human controllers can exercise the judgment of an ordinary seaman as well as a seaman physically onboard a vessel.").

236. *See* Veal, Tsimplis & Serdy, *supra* note 204, at 38 ("To the extent that the remote controllers of the UMV can use the technology to assess the circumstances and influence the UMVs movements in good time, there is no reason in principle why the seamanship standard may not be exercised remotely, to the extent that the relevant controller is sufficiently trained to discharge the duty.").

237. *See* Ringbom, *supra* note 38, at 155 ("It seems obvious that any effort to preprogram 'good seamanship' into an automated navigation program will be fraught with serious difficulties."); *see also* Veal, Tsimplis & Serdy, *supra* note 207, at 38 ("[Rule 2] presents clear difficulty to autonomous UMVs using algorithmic collision avoidance technology. Deciding when the overarching seamanship standard necessitates departure from the Rules is a highly sophisticated cognitive process beyond even the most impressive of modern control algorithms presently employed by UMVs. Because of this, autonomous UMVs, it is suggested, cannot yet comply with Rule 2 if they are unsupervised.").

238. *See* Chircop, *supra* note 21, at 4 ("Across the field of maritime regulation, a source of constant concern is the human factor in vessel operations. Autonomous shipping has the potential to substantially reduce or even remove the human factor in the operation and navigation of the ship…. In setting standards and rules for shipping, maritime regulation has frequently been concerned with the influence of human decision-making and conduct….").

239. *See* Ringbom, *supra* note 38, at 155.

applies, but also to exploit flexibility in the actions prescribed in a rule."[240] Nor do the COLREGS allow for the wooden application of one rule in an analytical vacuum from other rules that might be implicated, or from the possibility that derogation from a given rule may be appropriate—indeed, necessary—under the circumstances. Thus, unless and until a fully autonomous MASS can consistently discharge the requirements of Rule 2 in a manner "consistent not only with a human's strict interpretation, but also a human's common sense,"[241] fully autonomous vessel operations will likely fail to comply with both the letter and the spirit of COLREGS Rule 2 as currently written.

B. Maritime Safety and Security

Maritime safety encompasses a range of substantive requirements and procedural norms, ranging from specified emergency equipment to minimum standards for crew complement and training. While a number of conventions under the auspices of the IMO touch on maritime safety issues, the SOLAS Convention is particularly relevant in the context of remote-controlled and autonomous vessel operations. The SOLAS Convention is the IMO's flagship instrument for issues of maritime safety.[242] While it covers a range of maritime safety issues including, *inter alia*, lifesaving appliances (Chapter III), radiocommunications (Chapter IV), and carriage of cargoes and oil fuels (Chapter VI), this analysis will focus on SOLAS Chapter V's provisions on the safety of navigation, and the challenges of application to autonomous or remote-controlled operations.

Rule 14 of Chapter V, "Ship's Manning," provides an illustrative example. That provision specifies that "Contracting Governments undertake" to maintain or adopt measures to ensure that its national ships are "sufficiently

240. Michael R. Benjamin & Joseph A. Curcio, *COLREGS-Based Navigation of Autonomous Maritime Vehicles*, *in* 2004 IEEE/OES AUTONOMOUS UNDERWATER VEHICLES 32 (2004), https://www.researchgate.net/publication/4143876_COLREGS-based_navigation_of_autonomous_marine_vehicles.

241. *Id.*

242. *See The International Convention for the Safety of Life at Sea (SOLAS), 1974*, IMO, https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx ("The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships.").

and efficiently manned" from "the point of view of safety of life at sea."[243] As an initial matter, the term "manning" is itself in tension with the notion of fully autonomous vessel operations and, to a lesser extent, remote-controlled operations. Further, paragraph 2.1 of Regulation 14 dictates that the administration of each contracting government "shall establish appropriate minimum safe manning," which suggests that *some* manning is a threshold requirement.[244] Similarly, the Rule 14.3 mandate for establishing a common "working language" on all ships to "ensure effective crew performance in safety matters" underscores the implication of crew presence.[245] Nor is Regulation 14 an isolated example of provisions that assume the presence of a live crew. Regulation 15, for example, speaks to "tasks to be performed by the bridge team and the pilot."[246] Other provisions are less obvious but equally compelling in suggesting human involvement. Regulation 21, for instance, requires all ships to carry an updated copy of the International Aeronautical and Maritime Search and Rescue Manual.[247] This Regulation would be rendered superfluous if SOLAS Chapter V was interpreted to permit anything short of human presence.[248]

Still, the SOLAS Convention presents a more flexible regime than the COLREGS and thus may be more readily adaptive to MASS operations. For example, the SOLAS Convention explicitly provides for the possibility of "Exemptions"[249] and "Equivalents"[250] under certain conditions. Moreover, unless expressly provided otherwise, by its terms, SOLAS regulations do not

243. SOLAS, *supra* note 26, ch. V, regulation 14.1.

244. *Id.*, regulation 14.2.1. This provision underscores the breadth of IMO instruments implicated by MASS operations. Specifically, "safe manning" requirements established in SOLAS Chapter V are effectuated in part by the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers of 1978 (STCW Convention). The STCW Convention provides that "each Administration shall require every company to ensure that its ships are manned in compliance with the applicable safe manning requirements of the Administration." As Professor Chircop has noted, "where MASS are fully autonomous, they will render redundant the application of much of the STCW Convention . . .." Chircop, *supra* note 21, at 23.

245. SOLAS, *supra* note 26, ch. V, regulation 14.3.

246. *Id.*, regulation 15.1.

247. *Id.*, regulation 21.2.

248. The "rule against superfluities" is a canon of statutory interpretation that counsels against interpreting a provision "in a way that would render other provisions of the statute superfluous or unnecessary." *See* ESKRIDGE, GLUCK & NOURSE, *supra* note 199, at 1094.

249. *See* SOLAS, *supra* note 26, ch. 1, regulation 4.

250. *Id.*, regulation 5.

apply to large classes of vessels including, *inter alia*, warships, pleasure yachts, and fishing vessels.[251] By contrast, the COLREGS apply to "all vessels," and certain rules, including provisions regarding safe speed[252] and lookouts,[253] apply "at all times." Thus, while certain changes to SOLAS will likely be needed to fully address MASS operations, the enhanced flexibility provided by exemptions and equivalents will greatly facilitate the amendment process.

Maritime safety is inextricably linked to maritime security. Indeed, as Professors Kraska and Pedrozo have observed, "there is difficulty in separating maritime safety from maritime security, and the two sets of activities, which have developed independently, have become intertwined."[254] Autonomous and remote-controlled vessel operations, orchestrated through state-of-the-art digital networks and advanced computer infrastructure, present a unique maritime security risk in the form of cyberattack.[255] Following a devastating 2017 cyberattack against the leading maritime shipping company Maersk,[256] the global maritime industry is "now painfully aware that physical shipping operations are vulnerable to digital disruption."[257] Similarly, naval forces will have to contend with "a new breed of fighting in the form of cyberwarfare," including the hacking of remote-controlled and autonomous vessels.[258] At the same time, unmanned vessels in both the military and commercial contexts will likely be more susceptible to transnational criminal activity, including theft or piracy.[259] While cyber intrusion, enemy attack, and

251. *See id.*, regulation 3(a).

252. COLREGS, *supra* note 50, r. 6.

253. *Id.* r. 5.

254. KRASKA & PEDROZO, *supra* note 91, at 5.

255. Kimberly Tam & Kevin Jones, *Cyber-Risk Assessment for Autonomous Ships*, CYBER SECURITY (2018), https://www.researchgate.net/publication/325195302_Cyber-Risk_Assessment_for_Autonomous_Ships ("Although increased interconnectivity between ships and on-shore infrastructure have improved efficiency, and more is necessary to support autonomous ships, this trend also increases potential cyberattacks on maritime vessels."); *see also* Chircop, *supra* note 21, at 5 ("[T]he deployment of autonomous ships could produce new concerns, in particular with respect to the interaction with crewed ships in their vicinity and cyber security.").

256. John Churchill, *When the Screens Went Black*, MAERSK POST, Sept.-Nov. 2017, at 12, 12 (describing the "fight against the most damaging cyber-attack Maersk has ever experienced" and noting that "the experience of those early days will not soon be forgotten").

257. Chris Baraniuk, *How Hackers are Targeting the Shipping Industry*, BBC (Aug. 18, 2017), https://www.bbc.com/news/technology-40685821.

258. *See* Grome, *supra* note 19, at 50.

259. *See, e.g.*, Thibaut Eude, *Examining Autonomous Ships' Vulnerability to Piracy*, The MARITIME EXECUTIVE (Sept. 14, 2019), https://www.maritime-executive.com/blog/examining-autonomous-ships-vulnerability-to-piracy.

criminal interference are not the only maritime security threats posed by MASS operations, these issues suggest the scope and gravity of potential risks.

V. CONCLUSION

The era of autonomy on the world's oceans has indeed arrived. As the above discussion has aimed to demonstrate, this reality carries with it the promise of a more capable global regime for maritime SAR operations, superior law enforcement tools to detect and interdict maritime drug traffickers, and enhanced navigational safety. At the same time, it has stressed that embedded within each of these opportunities are formidable challenges and risks. Specifically, the precise contours of the duty to render assistance at sea, traditionally discharged by the master of a vessel, have yet to be defined in the context of MASS operations. This is particularly true for fully autonomous vessels, to whom the duty to render assistance does not yet attach. In the context of drug trafficking, autonomous vessels will not inure to the benefit of law enforcement officers alone but will likely become the next iteration of criminal organizations' pursuit of technology to advance their illicit aims. Finally, while autonomous vessel technologies may one day render ocean navigation a safer enterprise by reducing or removing human error, that day has not yet come.[260] Moreover, much of the extant navigational safety regime enshrined in international instruments, including the COLREGS and SOLAS Convention, presuppose human crews and at times demand uniquely human judgments. In closing, this article suggests that these challenges and risks, while formidable, are not insurmountable. However, adequately resolving these issues will require—in technical, legal, and diplomatic fields—the same ingenuity and resolve that has brought us to the threshold of an autonomous future at sea.

260. *See* Van Hooydonk, *supra* note 15, at 405 ("Anybody who reflects on how immensely difficult it can be for a ship's master and his pilot to bring a modern sophisticated ship safely to its berth, will probably think that a transition to fully crewless navigation is hopelessly unrealistic, or simply reject the idea outright as irresponsible, if not morally objectionable."); *see also supra* note 45 and accompanying text.