UNC SCHOOL OF LAW

NORTH CAROLINA JOURNAL OF INTERNATIONAL LAW

Volume 44
Number 4 *Online Edition*

Article 2

2019

Closing the Blast Doors: Constructing Comprehensive Space Safety Standards in a Galaxy Not So Far Away

Emma C. Nunn

Follow this and additional works at: https://scholarship.law.unc.edu/ncilj

 Part of the Law Commons

Recommended Citation

Emma C. Nunn, *Closing the Blast Doors: Constructing Comprehensive Space Safety Standards in a Galaxy Not So Far Away*, 44 N.C. J. INT'L L. & COM. REG. 1 (2019).
Available at: https://scholarship.law.unc.edu/ncilj/vol44/iss4/2

This Note is brought to you for free and open access by Carolina Law Scholarship Repository. It has been accepted for inclusion in North Carolina Journal of International Law by an authorized editor of Carolina Law Scholarship Repository. For more information, please contact law_repository@unc.edu.

Closing the Blast Doors: Constructing Comprehensive Space Safety Standards in a Galaxy Not So Far Away

Emma C. Nunn[†]

I. Introduction

In 2003 Gregory Nemitz sued NASA for infringing on his property rights by parking on "his" asteroid.[1] He alleged that he was entitled to parking fees, citing his registration on the Archimedes Institute website of the asteroid in question.[2] Unsurprisingly, his case was dismissed.[3] The court stated that his

---

[†] J.D. Candidate 2019, University of North Carolina School of Law. Notes & Comments Editor, *North Carolina Journal of International Law*. The author would like to thank her family, friends, and the journal staff for their support.

1 Complaint for Declaratory Judgement & Demand for Jury Trial at 12–13, Nemitz v. United States, No. CV–N030599–HDM–RAM, 2004 WL 3167042, at *1 (D. Nev. Apr. 26, 2004).

2 *Id.* at 11–13.

3 Nemitz v. United States, No. CV–N030599–HDM–RAM, 2004 WL 3167042, at *2 (D. Nev. Apr. 26, 2004).

Fifth, Ninth, and Tenth Amendment claims all failed, because there are no "constitutionally protected property interest[s]" in outer space.[4] Nemitz tried to argue that, because NASA had a declared purpose of facilitating "the fullest commercial use of space," he should prevail.[5] However, the court disagreed, stating that he could not prove the required "legal basis for his claim of a private property right on an asteroid."[6]

At the time, Nemitz's claim seemed frivolous and almost laughable. Now, however, it seems as though he will not be the first or the last person to sue over property rights, or any legal rights, for that matter, in space. Since the space race of the 1950s, the global space industry has rapidly grown from a field reserved for technologically-advanced nations to one accessible to anyone who can pay. By the early twenty-first century, nations began outsourcing national space programs to private companies, blurring the traditional distinction between "spacefaring" nations,[7] such as the United States, Russia, China, and Europe (represented by the twenty-two-nation cooperative European Space Agency),[8] and "non-spacefaring" states.[9] The advent of commercial space companies, such as SpaceX and Virgin Galactic, have made the growth of space tourism possible.

Each year, the United Nations General Assembly adopts a resolution entitled "International Cooperation in the Peaceful Uses of Outer Space," which, while not legally binding, offers guidance to states on the conduct of space activities.[10] With the commercialization of spaceflight, however, a more concrete set of laws is necessary to make the industry of space tourism as safe as possible. The international community should look to the international maritime standards of safety as a guide for this

---

4 *Id.* at *1.

5 National Aeronautics and Space Act, 51 U.S.C. § 20102(c) (2012).

6 Nemitz, 2004 WL 3167042, at *1.

7 Claudia Pastorius, *Law and Policy in the Global Space Industry's Lift-Off*, 19 BARRY L. REV. 201, 204 (2013) [hereinafter Pastorius] ("Spacefaring nations are defined as those countries that have built rockets powerful enough for launches into space and have deployed their own satellites into orbit.").

8 *Id.*

9 *See id.* at 206.

10 *Space Law: Resolutions*, U.N. OFF. FOR OUTER SPACE AFFS., (last visited Aug. 27, 2018), http://www.unoosa.org/oosa/en/ourwork/spacelaw/resolutions.html [https://perma.cc/Q9VY-M5C5].

process.

This note will proceed as follows. First, it will provide context and background on the need for safety standards in space. Next, it will analyze the three main parallels to space law and explain why maritime law has the most applicable standards for safety. Then, it will address various safety risks that have been highlighted by NASA and will conclude by suggesting modifications of the international maritime safety standards for application to space.

A. Do We Really Need International Safety Standards for Space?

In the twenty-first century, there has been a marked shift from State to non-State commercial actors in space.[11] "Between 2012 and 2013, commercial space products and services revenue grew 7% . . . while government spending decreased by almost 2%."[12] In 2010, NASA discontinued its human spaceflight program, and the United States moved to strengthen its private space industry.[13] Boeing, SpaceX, and Sierra Nevada have all been awarded contracts worth about $10 million dollars for services in space.[14] SpaceX, headed by Elon Musk, was the first commercial company to launch and return a spacecraft from orbit and developed its spacecraft to provide cargo-resupply services to the International Space Station.[15] Virgin Galactic and Bigelow Airspace both offer luxury trips to space to private individuals willing to pay a substantial price.[16]

With the space tourism industry slowly developing, it is necessary to acknowledge that there is no system of international safety regulation for private entities in space. Under current international treaties, States are liable for any activity of their citizens in space, whether they are acting in a public or private capacity.[17] This is unwise, as space tourism is clearly crossing

---

11 Paul S. Dempsey, *National Laws Governing Commercial Space Activities: Legislation, Regulation, & Enforcement*, 36 NW. J. INT'L L. & BUS. 1, 3 (2016) ("Private-sector commercial space activity is growing at a brisk pace, while governmental activity is declining.").

12 *Id.*

13 Pastorius, *supra* note 7, at 206.

14 *Id.* at 211.

15 Benjamin Perlman, *Grounding U.S. Commercial Space Regulation in the Constitution*, 100 GEO. L.J. 929, 938–39 (2012).

16 The trips cost $200,000 and $25 million, respectively. *Id.* at 938.

17 *See* Treaty on Principles Governing the Activities of States in the Exploration and

international lines. It would be prudent to adopt worldwide standards providing, at the very least, basic guidelines for conduct of private actors in space.

II. Background Law

The first official treaty governing human conduct in outer space was the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Celestial Bodies,[18] known colloquially as the "Outer Space Treaty." The United States, the United Kingdom, and the Soviet Union were the three principal parties at the time of the treaty's inception.[19] The Outer Space Treaty facilitates cooperation between these three superpowers.[20] It states that extraterrestrial exploration must be carried out "for the benefit and in the interests of all countries."[21] It further mandates the exclusive peaceful use of outer space and celestial bodies, barring any nation from stationing nuclear weapons or weapons of mass destruction in outer space.[22]

The Outer Space Treaty repeatedly emphasizes the need to keep space free from domination by any one nation, military occupation or otherwise. Article II explicitly bans any kind of "national appropriation" of space, the moon, or other celestial bodies.[23] Additionally, Article IV bars the construction of any kind of "military bases" in space.[24] Article XII states that any station should be open to representatives of other State parties on the basis of reciprocity.[25]

The Outer Space Treaty also deals with more technical issues such as jurisdiction in space. Under Article VIII, a State party that launches an object into outer space has jurisdiction over that object and any personnel inside it while in outer space or on a celestial

---

Use of Outer Space, including the Moon and Other Celestial Bodies art. VII, Jan. 27, 1967, T.I.A.S. No. 6347, 18 U.S.T. 2410 [hereinafter Outer Space Treaty].

18 *Id.*

19 *Id.*

20 S.G. Sreejith, *Whither International Law, Thither Space Law: A Discipline in Transition*, 38 CAL. W. INT'L L.J. 331, 345 (2008).

21 Outer Space Treaty, *supra* note 17, art. I.

22 *Id.* art. IV.

23 *Id.* art. II.

24 *Id.* art. IV.

25 *Id.* art. XII.

body.[26] Article VI states that parties "bear international responsibility for national activities in outer space," regardless of whether or not the actor is public or private.[27]

Article V of the Outer Space Treaty instructs nations to treat astronauts as "envoys of mankind" in outer space and requires that they provide to them "all possible assistance in the event of accident, distress, or emergency landing on the territory of another State Party."[28] The Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space (commonly known as "the Rescue Agreement"),[29] further elaborates on the treatment of astronauts in outer space. The Rescue Agreement mandates that if a party discovers that a spacecraft has suffered an accident or is experiencing conditions of distress, the party must notify the launching authority of the secretary general of the UN[30] in addition to taking any steps necessary to rescue the astronauts and rendering all necessary assistance.[31]

Under the Outer Space Treaty, individual states retain liability for all activity in space by citizens of their country, whether or not the actor is public or private.[32] Further information on regulation of objects in space is available in the Convention on Registration of Objects Launched into Outer Space.[33] A "launching State" is defined as "a State which launches or procures the launching of a space object"[34] or "a State from whose territory or facility a space object is launched."[35] A "space object" is defined as the "component parts of a space object" including "its launch vehicle

---

26 *Id.* art. VII.

27 Outer Space Treaty, *supra* note 17, art. VI.

28 *Id.* art. V.

29 G.A. Res. 2345 (XXII), annex, Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space (Dec. 19, 1967) [hereinafter Rescue Agreement].

30 *Id.* art. I.

31 *Id.* art. II.

32 Dempsey, *supra* note 11, at 6.

33 G.A. Res. 3235 (XXIX), annex, Convention of Registration of Objects Launched into Outer Space (Nov. 12, 1974) [hereinafter Registration Convention].

34 *Id.* art. I(a)(i).

35 *Id.* art. I(a)(ii).

and parts thereof."[36] States must create a registry of these objects,[37] and must inform the Secretary General of the UN once such a registry is established.[38] When States record the launch of an object, they must report the name of the launching State, the "appropriate designator of the space object," the date and territory of the launch, the basic orbital parameters, and the general function of the object.[39]

Another treaty that may become more relevant as more nations become spacefaring is the Agreement Governing the Activities of States on the Moon and other Celestial Bodies, or "the Moon Treaty."[40] The Moon Treaty states that all activities carried out on the moon must adhere to international law and that the moon shall be used for only peaceful purposes.[41] The Moon Treaty is similar to the Outer Space treaty in that it mandates that no nation can establish a military base on the moon, and prohibits the placement of nuclear weapons and other weapons of mass destruction on the moon.[42] However, there are several unique aspects of the Moon Treaty. For example, States have a duty to report any scientific discovery on the moon to the United Nations.[43] Nations are to treat the moon as part of the "common heritage of mankind" and cannot subject any part of the moon or its resources to national sovereignty.[44] An interesting facet of this agreement is that States may take samples of minerals and other substances on the moon to be used for scientific purposes, and they are encouraged to share them with other nations upon request.[45] The treaty also regulates the moon's environment as States are not to disrupt the balance of the existing environment of the moon through contamination or other means.[46]

The Rescue Agreement has the potential to be very important

---

36 *Id.* art. I(b).

37 *Id.* art. II.

38 *Id.*

39 Registration Convention, *supra* note 33, art. IV.

40 G.A. Res. 34/68, annex, Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Dec. 5, 1979) [hereinafter Moon Treaty].

41 *Id.* art. 3.

42 *Id.*

43 *Id.* art. 5.

44 *Id.* art. 11.

45 *Id.* art. 6.

46 Moon Treaty, *supra* note 40, art. 7.

when there are accidents in space.[47] Article I mandates that any contracting party must report to both the U.N. Secretary General and the launching authority when it has discovered a spacecraft from that launching authority that has suffered an accident, is "experiencing conditions of distress," or has made an emergency landing in that nation's territory or on the high seas.[48] Contracting parties must also take steps to rescue the personnel of such a spacecraft,[49] and return them promptly to the launching authority.[50]

A growing number of States are becoming spacefaring nations, or nations that "have built rockets powerful enough for launches into space and have deployed their own satellites into orbit."[51] Major spacefaring nations include Russia, the United States, France, China, Great Britain, India, Iran, North Korea, South Korea, and the joint program in the European Union.[52] The Outer Space Treaty and the Registration Convention establish the specific records States must maintain in monitoring private entry into space.[53] At least twenty-six States have enacted laws regulating space activity.[54] The United States, for example, requires all private-sector participants in space flights, both passengers and crew members, to sign informed consent notifications stating that "the United States Government has not certified the launch vehicle as safe for carrying crew or space flight participants."[55] On the other hand, Australia requires licensees to "receive approval from local ambulance, fire, and police authorities prior to launching."[56] Australian licensees must also receive environmental approvals to ensure the launches do not compromise public health or safety, or cause damage to property.[57] Additionally, the United States government requires organizations engaging in space flights to enter into reciprocal cross

47 Rescue Agreement, *supra* note 29.

48 *Id.* art. 1.

49 *Id.* art. 2.

50 *Id.* art. 4.

51 Pastorius, *supra* note 7, at 204.

52 *Id.*

53 *See* Dempsey, *supra* note 11, at 8 n.25.

54 *Id.* at 15—16.

55 *Id.* at 32.

56 *Id.* at 36.

57 *Id*.

waivers with its contractors, subcontractors, and customers.[58] In Russia, another major spacefaring nation, a license is required for all space activities by "all legal and natural persons of the Russian Federation" *and* operations of "foreign citizens and organizations operating under Russian Jurisdiction."[59]

III. Maritime Law as a Model for Space Law

While many successful space missions have been launched over the past half-century, space flight is not without risks. The United States has experienced its share of near misses and tragedies. When Neil Armstrong landed Apollo 11 on the moon, he had "less than 30 seconds worth of fuel remaining."[60] Apollo 12 was struck by lightning, which momentarily shut down electric power on the capsule.[61] An oxygen tank ruptured during the Apollo 13 mission to the moon, and fourteen NASA crew members lost their lives in the Challenger and Colombia space shuttles.[62] Other national space programs have suffered similar tragedies.[63] However, the unique difficulties with space travel greatly limit rescue options.[64]

As of right now, many nations, including the United States, do not have any clear cut commercial safety standards for space. Because of the lack of coherent international guidelines on how exactly States should structure safety standards for commercial space regulation, States vary widely in their choices to regulate commercial spaceflight. For example, in the United States, Congress put a moratorium on promulgation of regulations protecting the health and safety of the crew unless they related to serious or fatal injury.[65] While this may appear counterintuitive, Congress enacted this moratorium in an effort to promote the development of space operation programs within the private

58 *Id.* at 32.

59 Dempsey, *supra* note 11, at 27.

60 HEALTH STANDARDS FOR LONG DURATION AND EXPLORATION SPACEFLIGHT: ETHICS PRINCIPLES, RESPONSIBILITIES, AND DECISION FRAMEWORK 46 (Jeffrey Kahn et. al. eds., 2014) [hereinafter HEALTH STANDARDS FOR SPACEFLIGHT].

61 *Id.*

62 *Id.*

63 *See, e.g.*, Alexey Timofeychev, *The dark side of the Soviet space program: 3 tragic accidents*, RUSSIA BEYOND (Jan. 29, 2018), https://www.rbth.com/science-and-tech/327410-dark-side-of-space-program [https://perma.cc/MAU2-MAY8].

64 HEALTH STANDARDS FOR SPACEFLIGHT, *supra* note 60, at 46.

65 Dempsey, *supra* note 11, at 32.

sector.[66] This may be fine for a nation as technologically advanced as the United States, but not every nation has the same capabilities and access to technology.

Additionally, technical qualifications of commercial spaceflight operators and licensing procedures differ across the globe.[67] Increasingly, States are mandating licenses prior to any space activity.[68] However, the Outer Space Treaty does not provide any guidance as to how to structure domestic law, so licensing is at each State's discretion.[69] Some States focus on the ability to finance the proper level of insurance, while others look at technical qualifications.[70]

Three main parallels have been drawn to space law: "air law, law of the sea, and the Antarctic Treaty."[71] The unifying theme amongst these three "is that all regulate areas which have somewhat anomalous physical features."[72] From a purely physical standpoint, Antarctica is the most geographically similar to outer space.[73] However, of these three fields of law, maritime law has the most comprehensive international standards for vessels to promote maximum safety and minimize pollution.[74] These laws should be used as a model for constructing international outer space safety standards.

The Antarctic Treaty was meant to serve as a prototype for future covenants regulating outer space.[75] Antarctica and outer space are similar in terms of geographic and natural resource

---

66 *Id*.

67 *See id*. at 19.

68 *Id*.

69 *See id*. at 14—15.

70 *See id.* at 28–29. For example, in South Korea, licenses are denied if applicants are bankrupt. *Id.* at 29. Alternatively, in Russia, applicants must demonstrate sufficient technical knowledge of the matter. *Id.* at 30.

71 Sreejith, *supra* note 20, at 364.

72 *Id*.

73 *See id.* at 365.

74 *See generally The Principal Regulations Governing Maritime Safety*, INT'L CHAMBER OF SHIPPING (2017) (U.K.), http://www.ics-shipping.org/shipping-facts/safety-and-regulation/the-principal-regulations-governing-maritime-safety [https://perma.cc/2ZDH-BEY2] (establishing the multiple regulations on maritime safety and pollution that have been adopted by the International Maritime Organization).

75 Sreejith, *supra* note 20, at 364.

accessibility.[76] Additionally, like outer space, there is a lack of power belonging to any one State in Antarctica—though seven nations have made territorial claims of some sort, not all countries recognize them.[77] The continent is governed by the Antarctic Treaty system, a regulatory framework developed by the various Party States to the Antarctic Treaty.[78] This system bears many similarities to the rules for space which are established by the Outer Space Treaty.[79] For example, the Antarctic must be used for only peaceful purposes, weapons testing is prohibited, and military personnel and equipment are only allowed to the extent that they will be used for scientific research or peaceful purposes.[80] The treaty further states that no territorial claims may be asserted by any nation, and it gives States jurisdiction over their own personnel in Antarctica.[81]

While there are clearly many parallels between space law and Antarctic law, there are aspects of maritime law that make it more useful to space law as humans move towards the commercialization of outer space. For example, resource mining and tourism are two areas where the law of the sea may have more applicability to space law. The only real resource in Antarctica that has been exploited is fish, and tourism is sparse. In order to regulate tourism and trade in space, the international community could potentially look to the law of the sea.

Under current international law, the sea is divided into three zones: inland waters, territorial waters near coastlines, and the high

---

76 *Id.* at 365.

77 *Antarctica*, THE CIA WORLD FACTBOOK (2017), https://www.cia.gov/library/publications/the-world-factbook/geos/ay.html [https://perma.cc/DN73-RLN5].

78 *Id.* The Antarctic Treaty system is comprised of the Antarctic Treaty, Dec. 1, 1959, 12 U.S.T. 794, 402 U.N.T.S. 71, the Convention for the Conservation of Antarctic Marine Living Resources, May 20, 1980, 33 U.S.T. 3476, 1329 U.N.T.S. 48, the Convention for the Conservation of Antarctic Seals, June 1, 1972, 29 U.S.T. 441, 11 I.L.M. 251, the Protocol on Environmental Protection of the Antarctic Treaty, Jan. 14, 1998, 30 I.L.M. 1455, as well as numerous recommendations and measures adopted by participating States at annual Antarctic Treaty consultative meetings. See *The Antarctic Treaty System*, SCI. COMMITTEE ON ANTARCTIC RES. (last visited Aug. 27, 2018), https://www.scar.org/policy/antarctic-treaty-system/ [https://perma.cc/CMB9-ZRMQ], for further reading on the Antarctic Treaty system.

79 *Antarctica*, *supra* note 77.

80 Antarctic Treaty, *supra* note 78, at art. I.

81 *Id.*

seas—the area most analogized to airspace and traditionally thought of as outside the jurisdiction of any nation.[82] The International Maritime Organization, located in London, has adopted several international shipping conventions regulating the high seas, including SOLAS (International Convention for the Safety of Life at Sea), MARPOL (International Convention for the Prevention of Pollution from Ships), COLREG (Convention on the International Regulations for Preventing Collisions at Sea), STCW (International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers), and the ISM (International Safety Management Code).[83]

The International Convention for the Safety of Life at Sea, or SOLAS, was first adopted in 1914.[84] The most recent version was adopted in 1980.[85] SOLA's main objective is "to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety."[86] Flag States must make sure that vessels operating under their flag comply with safety requirements, but any contracting government may inspect the ships of any other contracting government if there are "clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention."[87] Other important provisions concern the construction requirements of both passenger and cargo ships, fire safety measures, lifesaving appliances and their arrangements, and various navigation features to ensure safety.[88] All of these provisions could be adjusted so as to accommodate the unique concerns of space and serve as models for a similar agreement regulating space.

The Convention on the International Regulations for Preventing Collisions at Sea, or COLREG, was adopted in 1972.[89] COLREG

---

82 Nancy L. Firak & Kimberly A. Schmaltz, *Air Range: Choice of Law for International Torts Occurring in Flight Over International Waters*, 63 ALB. L. REV. 1, 38 (1999).

83 *The Principal Regulations Governing Maritime Safety*, *supra* note 74.

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

85 *Id.*

86 *Id.*

87 *Id.*

88 *Id.*

89 International Regulations for Preventing Collisions at Sea, Oct. 20, 1972, 28 U.S.T. 3459, 1050 U.N.T.S. 16 [hereinafter COLREGs].

creates traffic schemes for the seas, including safe speed recommendations, visibility requirements, conduct of vessels when approaching each other, light requirements, and sounds and signals.[90] While some of these provisions may seem ill-suited to governing space travel, it is still wise to adopt some kind of universal system of traffic patterns for vehicles during launch and while in orbit.

The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers, or STCW, was adopted to "promote safety of life and property at sea and the protection of the marine environment by establishing in common agreement international standards of training, certification and watchkeeping for seafarers."[91] These standards were revised in 2010, and cover everything from character and fitness to technology-related requirements.[92] It is important to offer some sort of mandatory system credentialing when it comes to space flight, as the requirements vary substantially from nation to nation.

Finally, the International Convention for the Prevention of Pollution from Ships (MARPOL) could serve as a model for preventing pollution by spacecraft.[93] MARPOL focuses primarily on oil and the discharge of noxious liquid and sewage, which are less of a concern in space law.[94] However, these provisions could be amended to accommodate the unique pollution concerns that come with space, such as free-floating debris from discarded material and light pollution.

IV. What Safety Concerns Must be Accommodated?

According to NASA, spaceflight involves "a high degree of known risks" as well as "uncertain and unforeseeable risks."[95] These risks exist during all phases of any mission, though launch is identified as the riskiest period.[96] Short-term health consequences

---

90 *Id.*

91 International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers, July 7, 1978, 1361 U.N.T.S. 2 [hereinafter STCW].

92 *Id.*

93 International Maritime Organization, International Convention on the Prevention of Pollution from Ships, Feb. 17, 1973, 1340 U.N.T.S. 184 [hereinafter MARPOL].

94 *Id.*

95 Health Standards for Spaceflight, *supra* note 60, at 25.

96 *Id.*

of space travel include nausea, fatigue from acute radiation exposure, injury, and blurred vision.[97] Long-term consequences include radiation-induced cancers and loss of bone mass.[98] NASA has divided space health risks into five categories: (1) behavioral health and performance; (2) human health countermeasures (including bone metabolism, physiology, nutrition, immunology, cardiac and pulmonary physiology, and injury); (3) space radiation; (4) space human factors and habitability; and (5) exploration medical capabilities.[99]

NASA has grouped its current human spaceflight safety standards into three categories: (1) fitness for duty standards; (2) space permissible exposure limits (which set ceilings on risk exposures during missions); and (3) permissible outcome limits (which give guidelines as to acceptable maximum decrease or change in biology and physiology).[100] Reviews of these health standards are conducted every five years.[101] Additionally, there are high standards for astronaut selection.[102] While the commercial spaceflight industry need not be concerned with the long-term effects of outer space on the human body, the international community should take steps to implement regulations to minimize the short-term effects of exposure to outer space.

A risk NASA has identified that could impact both private and governmental spaceflight is vision impairment.[103] Astronauts have long reported vision changes during spaceflight, but until recently, these changes were assumed to be transient and isolated.[104] There have been documented reports of astronauts who spend more time in space becoming more farsighted.[105] There are several hypotheses to explain this, including elevated carbon dioxide in the space and

---

97 *Id.*

98 *Id.* There are obviously more long-term physical consequences of space travel, but few with comprehensive bodies of research.

99 *Id.* at 29.

100 *Id.* at 33–34.

101 Health Standards for Spaceflight, *supra* note 60, at 38.

102 *Id.* at 39–40. These standards include vision that is or is correctable to 20/20 in both eyes and blood pressure below 140/90, among others.

103 *Id.* at 47.

104 *Id.*

105 *Id.*

radiation exposure.[106] There is also evidence that the same processes may cause intracranial pressure.[107] This is an area in which NASA identified international parameters as "lacking."[108]

The international community should also consider creating standards for commercial space flight for bone demineralization due to exposure to microgravity[109] and radiation exposure.[110] The first is a "well-studied phenomenon," yet scientists are still unsure "in what ways microgravity-induced bone loss might be similar to, or different from, osteoporosis."[111] Radiation exposure has both acute immediate and long-term secondary risks. Immediate effects include fatigue, nausea, and vomiting.[112] Long-term effects of chronic exposure to radiation include an increase in the risk of cancer, tissue degeneration, development of cataracts, and adverse effects on the central nervous system, cardiovascular system, immune function, and vision.[113]

V. Reforming Space Law as Guided by Maritime Law

The international community is aware that there must be some kind of international entity or agreement to regulate commercial space exploration.[114] Some have suggested that the International Civil Aviation Organization (ICAO) serve as a model.[115] The ICAO is "a technical organization with a central role in establishing international standards and practices, collecting statistics, and overseeing all the non-economic aspects" of commercial aviation.[116] The ICAO works to create multilateral approaches to international airspace regulation.[117] An advantage to following a multilateral approach is that the area of nations that actually have access to

106 *Id.* at 48.

107 Health Standards for Spaceflight, *supra* note 60, at 48–49.

108 *Id.* at 48.

109 *Id.* at 57–60.

110 *Id.* at 60.

111 *Id.* at 57.

112 *Id.* at 60.

113 Health Standards for Spaceflight, *supra* note 60, at 60.

114 JAMES A. VEDDA, INTERNATIONAL COMMERCIAL SPACEFLIGHT REGULATION: ASSESSING THE OPTIONS (Ctr. for Space Policy and Strategy ed., 2017).

115 *Id.*

116 *Id.*

117 *Id.* at 3.

spaceflight is relatively small, so there would be fewer parties advocating for their particular interests.[118] Additionally, bilateral agreements on technical standards and safety issues have generally garnered a lot of support.[119]

Others have suggested that—instead of creating a separate parallel organization for international spaceflight regulations—the ICAO should be expanded to include space flight.[120] This would be a less-difficult process, as the ICAO already has 191 members and decades of experience.[121] However, the ICAO has very little space expertise and very few member States of the ICAO are spacefaring nations.[122] Regardless of what organization creates the agreement, it is clear there must be international standards in place to make commercial space use as risk free as possible.

A. Structural Requirements to Guarantee Astronaut Safety

At a base level, the best way to begin the process of implementing safety standards would be using SOLAS as a model for safety requirements of commercial spacecraft vehicles. Chapter I of SOLAS includes general provisions,[123] including a regulation permitting one country to survey another country's ship for safety purposes.[124] This regulation should be adapted to space law at some point, especially in situations outlined in the Rescue Agreement where one party is returning the astronauts or property of another.[125] It might be too controversial to implement while the space industry is still incipient, as nations are very secretive about the development of spacecraft. However, if the commercial space industry reaches the point where space tourism and commercial space travel are the norm, it would be wise to adopt such a principle.

Chapter II-1 of SOLAS requires passenger ships to maintain watertight compartments that maintain the stability of the ship's hull after assumed damage.[126] To accommodate space travel, these

---

118 *Id.*

119 VEDDA, *supra* note 114.

120 *Id.*

121 *Id.* at 5.

122 *Id.*

123 SOLAS, *supra* note 84, ch. I.

124 *Id.* ch. I, reg. 13.

125 *See* Rescue Agreement, *supra* note 29.

126 SOLAS, *supra* note 84, ch. II-1.

provisions could be adopted to mandate that ships be airtight, not watertight. Additionally, under SOLAS, passenger ships have the most stringent standards for maintaining a watertight structure,[127] undoubtedly because non-crew passengers on marine vessels are there for transport or pleasure. In the context of space travel, there does not need to be a distinction between crew and non-crew passengers. Space travel is equally risky for crewmembers and passengers alike. Requiring that all ships be airtight will hopefully address scientists' concerns about radiation damage as well as make spacecraft safer overall.

Any standards of safety in outer space should also adopt Regulation 25(a) of Chapter II-1,[128] which requires that all ships have an emergency source of power "to ensure . . . that a fire or other casualty to the machinery space . . . will not interfere with the supply or distribution of emergency power."[129] This regulation might need to be expanded if adapted to space, with special provisions for which systems an emergency energy source must continue to power.[130]

SOLAS Chapter VIII, which deals with nuclear ships, should also be used as a model for safety regulations in space.[131] SOLAS defines a nuclear ship as "a ship provided with a nuclear power plant."[132] Scientists have identified radiation exposure as both a short and long-term risk of space travel;[133] therefore, this chapter is important for building the foundation of international safety standards in space. Regulation 6 of Chapter VIII[134] requires that there be "measures to ensure that there are no unreasonable radiation or other nuclear hazards" to the passengers or the public.[135] This regulation could be modified to fit outer space by drafting a

---

127 *Id.*

128 SOLAS, *supra* note 84, ch. II-1, reg. 25.

129 *Id.*

130 *See id.* reg. 23(a). Under SOLAS, emergency and non-emergency power sources only have to power "services essential for safety." *Id.* In an international regulatory scheme concerning safety in space, any agreement may have to list examples of what functions must retain power in the event of an emergency.

131 *Id.* ch. VII.

132 *Id.* ch. I, reg. 2.

133 *See* Health Standards for Spaceflight, *supra* note 60.

134 SOLAS, *supra* note 84, ch. VIII, reg. 6.

135 *Id.*

provision that allows for a maximum amount of radiation a passenger may be exposed to on a spacecraft.

B. Licensing and Training Requirements to Insure Safety

In addition to creating structural requirements to guarantee the safety of astronauts, any kind of international regime to ensure safety in space should include some kind of universally-applicable licensing requirements. Right now, nations vary greatly in the kind of certification they require for astronauts and those who launch shuttles.[136] These types of regulations had a similar start in maritime law. Initially, individual governments created certification ratings and standards, without referencing other nations' practices.[137] Due to the wide variety in certification standards stemming from these disparities, the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) was introduced in 1978.[138] "The [STCW provides] minimum standards [. . .] for training and certification [. . .] which countries must either meet or exceed."[139]

Unlike other conventions promulgated by the IMO, "[p]arties [. . .] are required to provide detailed [proof of] compliance with the convention," including "education and training courses, certification procedures, and [any] other factor relevant to implementing the convention."[140] Any similar regulation scheme in space should mimic this measure, especially since these standards might change where space is concerned as research is constantly bringing new hurdles and complications of space travel to light.

The STCW lays out certain mandatory requirements of certification, such as being eighteen years of age and having at least one year of training.[141] There are different levels of required

---

136 *See generally* Dempsey, *supra* note 11 (explaining the different approaches States are taking to regulate space activities).

137 *About the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)*, INT'L MAR. ORG. (2018), http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx [https://perma.cc/JMZ2-3TS9**]**.

138 *Id.*

139 *Id.*

140 *Id.*

141 *See, e.g.*, STCW, *supra* note 91, at reg. II/4.

certification, depending on the size of the load the ship is carrying.[142] While space law safety standards should include mandatory requirements of certification, because of the inherent danger of space travel, it may be wiser to distinguish between passengers and crew members, rather than requiring different levels of certification for different crew members. This way, in case of an emergency, any crew member will be able to assist another. Another aspect of the STCW that will need to be modified to accommodate space travel is the age requirement. The STCW provides for crew members as young as sixteen working in certain areas, so long as they are certified.[143] Any regulations dealing with space should probably impose a higher age limit until space travel is more developed.

The STCW also provides for certain requirements on hours of work and rest, and as of 2010, provisions for the prevention of drug and alcohol abuse.[144] The convention requires "a minimum of 10 hours of rest in any 24-hour period," except in cases of emergency.[145] The rest period may be divided into no more than two parts, one of which must be at least six hours.[146] While any provisions on drug and alcohol abuse should be limited to the preflight period,[147] there should surely be some kind of international standard on hours astronauts are required to rest after working, as some nations are more likely than others to expect astronauts to forgo sleep in favor of conducting more research.

C. Preventing Pollution and Making Space Safe for Everyone Else

The most-difficult maritime convention to adapt to outer space is likely the International Convention for the Prevention of Pollution from Ships (MARPOL).[148] MARPOL focuses primarily on

142 *Id.*

143 *Id.* at reg. II/6.

144 STCW, *supra* note 91, at ch. VIII, sec. A/VIII-1.

145 *Id.*

146 *Id.*

147 Will Durham, *Report claims "heavy" alcohol use by NASA astronauts,* REUTERS (July 27, 2007), https://www.reuters.com/article/us-space-nasa/report-claims-heavy-alcohol-use-by-nasa-astronauts-idUSN2732879120070727 [https://perma.cc/GLC6-XCQL] (describing an incident in which astronauts were investigated for potentially abusing alcohol in the preflight period).

148 *About the International Convention for the Prevention of Pollution from Ships*

preventing pollution from "harmful substances," primarily oil or noxious liquids.[149] A "harmful substance" under Article 2 is any substance that, when introduced into the sea "is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea."[150] The sea is fundamentally different from space in this respect, as there is no human habitat or extraterrestrial life (that we know of) to worry about damaging. Additionally, oil and noxious liquids are not particularly hazardous to ships in outer space.

Nevertheless, some pollution in space does need to be monitored and reduced. As more nations move into space, floating space debris are becoming a pressing technical issue.[151] "Space debris" include defunct satellites, booster parts, and bits of metal and scrap.[152] In 2013, NASA reported over 500,000 trackable pieces of space debris in orbit.[153] Provisions of MARPOL that could be modified to accommodate space are Articles 7 and 8, which require "all possible efforts shall be made to avoid a ship being unduly delayed or detained,"[154] and for "a report of an incident without delay" after an incident involving harmful substances.[155] Spacecraft could have a duty to report the sighting of space debris to an international body, and ensure that other vessels are aware when they eject such debris.

VI. Conclusion and Recommendations

While the global space industry is still in its infancy, there is no doubt that it will continue to grow in the coming years. There is a myriad of opportunities in outer space to help those on Earth, from mining resources on the moon[156] to preemptively detecting human

---

(MARPOL), INT'L MAR. ORG., http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx [https://perma.cc/ZLU3-63FA].

149 *Id.*

150 MARPOL, *supra* note 93, art. 2.

151 JOSHUA HAMPSON, THE NIKASEN CENTER, THE FUTURE OF SPACE COMMERCIALIZATION 13 (2017).

152 *Id.*

153 *Id.*

154 MARPOL, *supra* note 93, art. 7.

155 *Id.* art. 8.

156 HAMPSON, *supra* note 151, at 17.

rights violations from space.[157] Furthermore, the shift from government-sponsored space programs to commercial space programs allows more parties a chance to take advantage of these resources.

However, as befits a major industry, there must be some kind of international safety standards regulating commercial spacecraft. The current practice of allowing each government to promulgate its own safety and certification procedures will simply not do—space travel is too unique and dangerous. Space law should take its cues from maritime law, and provide comprehensive regulations on the structure of spacecraft, parameters for licensing, and waste monitoring. By adopting an approach focused on cooperation and safety, the global space industry can plot a successful course toward a bright future.

157 Steven Livingston, *Satellite Imagery Augments Power and Responsibility of Human Rights Groups*, BROOKINGS (June 23, 2016), https://www.brookings.edu/blog/techtank/2016/06/23/satellite-imagery-augments-power-and-responsibility-of-human-rights-groups/ [https://perma.cc/77HE-6RJH]. Commercial satellite images from space have been used to help prove human rights violations, such as locating mass graves and showing the destruction of two towns in Nigeria. *Id.*